Abstraction of Groundwater from the Millstream Supporting Document

4 April 2025

WATER CORPORATION

Executive Summary

Water Corporation proposes to continue to abstract a total of up to 6 gigalitres per annum (GL/a) of groundwater until 2032, with an additional contingency of up to 3GL/a to 2027, from the Millstream aquifer as a secondary source for the West Pilbara Water Supply Scheme (WPWSS). The proposal is located near the old Millstream Homestead, adjacent to the Fortescue River, about 130 km south of Roebourne. Figure 2 and Figure 3 show the location of Millstream Borefield, Millstream National Park and Wetlands.

A summary of the proposal is provided in Table ES1 and the key proposal elements (e.g. physical, operational activities) which have the potential to cause an impact on the environment are summarised in Table ES2.

Table ES1: General proposal content description

Proposal title	Abstraction of Groundwater from the Millstream aquifer
Proponent name	Water Corporation
Short description	Water Corporation proposes to continue abstracting groundwater from the Millstream aquifer to supply WPWSS. The proposal is to continue groundwater abstraction from the Millstream aquifer up to 6GL/a until 2032 with a contingency of up to 3GL/a until 2027. The proposal allows for groundwater abstraction from Millstream Borefield as a secondary water source for the WPWSS.

Table ES2: Proposal content elements

Proposal element	Location / description	Maximum extent, capacity or range
Physical elements		
Millstream Borefield	Figure 2	Production Bores PB1, PB2, PB3, PB4, PB5, PB6 - Crown Reserve 36991, Lot 55 Millstream Production Bores (unequipped) PB7, PB8, PB9, PB10, PB11, PB12 - Crown Reserve 36991, Lot 58 Millstream
Construction elements		
Not applicable – groundwater abstraction is currently occurring with established assets		
Operational elements		
Groundwater abstraction from the Millstream aquifer	Figure 2	Continue groundwater abstraction up to 6GL/a until 2032 with an additional contingency up to 3GL/a to 2027
Rehabilitation		
Not applicable – assets are in operation		
Commissioning		
Not applicable – assets are in operation		
Decommissioning		

The need and timing of the decommissioning of groundwater bores and associated infrastructure will be as confirmed as and when the long-term operation of the Millstream aquifer as a source for the WPWSS is defined.		
Other elements which affect extent of effects on the environment		
Proposal time*	Maximum project life	Abstraction up to 6GL/a until 2032, and up to 3GL/a contingency to 2027
	Construction phase	Not applicable
	Operations phase	See maximum project life
	Decommissioning phase	Not defined

Key Environmental Factors

The Environmental Protection Authority (EPA) identified the following preliminary key environmental factors for this Proposal:

- Inland Waters
- Social Surroundings
- Flora and Vegetation
- Terrestrial Fauna
- Subterranean Fauna

Water Corporation does not consider Landforms as a key environmental factor for assessment, as the intent of this factor is for banded iron formations, mesas, dunes and dune fields, caves and cave systems which is not relevant to the Proposal.

Table ES3 summarises relevant information on the potential impacts, mitigation and outcomes for each of the preliminary key environmental factors identified by the EPA. The appendices provide supporting studies and investigations undertaken to inform this Environmental Review, the key elements of which are included in this document.

Table ES3: Summary of potential impacts, proposed mitigation and outcomes

Inland Waters	
EPA objective	The EPA Objective for this key environmental factor is to maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.
Policy and guidance	• Statement of environmental principles, factors, objectives and aims of environmental impact assessment (EIA) (EPA, 2023). • Environmental Factor Guideline - Inland Waters (EPA, 2018). • Inland Waters of the Pilbara, Western Australia (Part 1). Environmental Protection Authority Technical Series No 10. January 1900 (EPA, 1988). • A Directory of Important Wetlands in Australia Third Edition (Environmental Australia, 2001). • Antao, M. 2013, Pilbara monitoring program to support the Pilbara groundwater allocation plan, Department of Water, Government of Western Australia. • Rights in Water and Irrigation Act 1914.
Potential impacts	**Groundwater** • Changes in groundwater levels due to abstraction. **Inland surface waters**

	• The Millstream Wetlands may be indirectly impacted by groundwater abstraction altering the volume of the springflow from the aquifer entering Millstream Wetlands pools and rivers.

Mitigation	**Avoid**
	
	Groundwater abstraction from the Millstream aquifer cannot be totally avoided due to the requirement to maintain an essential public water supply and the current absence of alternative supply options. Water Corporation are actively progressing other water supply options to minimise the reliance on the Millstream aquifer as a source for the WPWSS.
	
	Minimise
	
	• Abstraction of up to 6GL/a has been limited until 2032 with a contingency of up to 3GL/a until 2027. Should abstraction continue beyond these dates, it will be reduced in alignment with an updated sustainable yield assessment and subject to an assessment in accordance with the relevant statutory decision-making process.
	• Obtain and comply with approvals under, *Rights in Water and Irrigation Act 1914.*
	• Monitor groundwater levels and pool water levels in accordance with the Water Resource Management Operation Strategy (WRMOS) (Appendix B).
	• Undertake contingency actions outlined in WRMOS if criteria are breached. Contingency actions include:
	  ○ Increased monitoring and reporting.
	  ○ Implement supplementation plan.
	  ○ Undertake Scheme response, commence negotiations to take additional water from other sources (e.g. Rio Tino Iron Ore's (RTIO) Bungaroo source).
	  ○ Critical response supplementation in accordance with targets set in WRMOS.
	  ○ Reduce take.
	
	Rehabilitate
	
	• No rehabilitation is anticipated as groundwater abstraction is not predicted to significantly impact the Millstream Wetlands and pools.

Outcomes	The sustainable yield and allocation planning studies and real-life monitoring data for the proposal has predicted and shown that Abstraction up to 9GL/a does not adversely affect pool water levels; antecedent hydroclimatic conditions are the primary driver. Pool water levels have recovered following periods of groundwater abstraction greater than 9GL/a. Consequently, the proposal is not expected to result in long-term, permanent observable change, any observable changes are likely to be attributable to climatic events and the proposal is not likely to result in significant impacts to inland waters. Potential impacts to inland water quality can be appropriately managed under the RiWI Act via a groundwater abstraction licence. Based on the above, the Proposal is expected to be able to be implemented in a way that maintains hydrological regimes and quality of groundwater and surface water so that environmental values are protected. The EPA objective for this factor is therefore able to be met.
Social Surroundings	
EPA objective	The EPA Objective for this key environmental factor is to protect social surroundings from significant harm.
Policy and guidance	• Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023). • Environmental Factor Guideline - Social Surroundings (EPA, 2023). • EPA (2023) Technical Guidance Environmental impact assessment of Social Surroundings – Aboriginal cultural heritage. • *Aboriginal Heritage Act 1972* (AH Act). • *Rights in Water and Irrigation Act 1914* (RiWI Act).

<table>
<tr><td>Potential impacts</td><td>No clearing is proposed and no direct impacts to the Millstream Wetlands and other cultural places are expected as a result of implementation of the proposal.

No impacts are expected to the Aboriginal Cultural Heritage (ACH) registered site including Millstream Homestead, burial grounds or archaeological sites as the proposal does not include any clearing and the proposal activities are limited to groundwater abstraction.

The cultural values of the Millstream Wetlands may be indirectly impacted by groundwater abstraction altering the volume of the springflow from the aquifer entering Millstream Wetlands pools and rivers.</td></tr>
<tr><td>Mitigation</td><td>Avoid

Groundwater abstraction from the Millstream aquifer cannot be totally avoided due to the requirement to maintain an essential public water supply and the current absence of alternative supply options. Water Corporation are actively progressing other water supply options to minimise the reliance on the Millstream aquifer as a source for the WPWSS.

Minimise
Abstraction of up to 6GL/a has been limited until 2032 with a contingency of up to 3GL/a until 2027. Should abstraction continue beyond these dates, it will be reduced in alignment with an updated sustainable yield assessment and subject to an assessment in accordance with the relevant statutory decision-making process.
Obtain and comply with approvals under, Rights in Water and Irrigation Act 1914.
Monitor groundwater levels and pool water levels in accordance with the WRMOS (Appendix B).
Undertake contingency actions outlined in WRMOS if criteria are breached. Contingency actions include:
Increased monitoring and reporting.
Implement supplementation plan.
Undertake Scheme response, commence negotiations to take additional water from other sources (e.g. RTIO Bungaroo source).
Critical response supplementation in accordance with targets set in WRMOS.
Reduce take.
Rehabilitate

No rehabilitation is anticipated as groundwater abstraction is not predicted to significantly impact the Millstream Wetlands and pools.</td></tr>
<tr><td>Outcomes</td><td>The observed and future potential changes to culturally important pool levels within the Millstream Wetlands are primarily due to antecedent hydroclimatic conditions and are not significant, nor directly related to groundwater abstraction. Groundwater abstraction is not a clear direct link to observations to pool and river levels within the Millstream Wetlands and these observations are not considered significant affects. The proposal is not likely to result in significant impacts to cultural values and the EPA objective “To protect social surroundings from significant harm” can be met</td></tr>
<tr><td colspan="2">Flora and Vegetation</td></tr>
<tr><td>EPA objective</td><td>The EPA Objective for this key environmental factor is to protect flora and vegetation so that biological diversity and ecological integrity are maintained.</td></tr>
<tr><td>Policy and guidance</td><td>Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023).
Environmental Factor Guideline - Flora and Vegetation (EPA, 2016).
Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016).</td></tr>
</table>

	• Approach to vegetation monitoring in the Pilbara – West Pilbara Water Supply Scheme. (DoW, 2013). • Approach to vegetation monitoring in the Pilbara – guidance for proponents (DoW, 2024) (updated). • *Biodiversity Conservation Act 2016* (BC Act). • *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).
Potential impacts	• No clearing of vegetation is required for this proposal and no direct impacts to flora and vegetation are proposed. • The riparian, riverine and delta vegetation, and priority flora associated with the Millstream Wetlands, may be indirectly impacted by groundwater abstraction altering the volume of the springflow from the aquifer entering Millstream Wetlands pools and rivers.

Mitigation	**Avoid**
	
	Groundwater abstraction from the Millstream aquifer cannot be totally avoided due to the requirement to maintain an essential public water supply and the current absence of alternative supply options. Water Corporation are actively progressing other water supply options to minimise the reliance on the Millstream aquifer as a source for the WPWSS.
	
	Minimise
	
	• Abstraction of up to 6GL/a has been limited until 2032 with a contingency of up to 3GL/a until 2027. Should abstraction continue beyond these dates, it will be reduced in alignment with an updated sustainable yield assessment and subject to an assessment in accordance with the relevant statutory decision-making process.
	• Obtain and comply with approvals under, *Rights in Water and Irrigation Act 1914.*
	• Monitor groundwater levels and pool water levels in accordance with the WRMOS (Appendix B).
	• Undertake contingency actions outlined in WRMOS if criteria are breached. Contingency actions include:
	    o Increased monitoring and reporting. Vegetation health monitoring has been undertaken as a contingency measure.
	    o Implement supplementation plan.
	    o Undertake Scheme response, commence negotiations to take additional water from other sources (e.g. RTIO Bungaroo source).
	    o Critical response supplementation in accordance with targets set in WRMOS.
	    o Reduce take.
	Rehabilitate
	
	• No rehabilitation is anticipated as groundwater abstraction is not predicted to significantly impact the vegetation associated with the Millstream Wetlands and pools.

Outcomes	The observed and future potential impacts on riverine and delta vegetation within the Millstream Wetlands are primarily due to local water availability as well as the acute impacts from fire and floods. The local water availability is strongly correlated with antecedent hydroclimate including direct rainfall, surface water runoff and springflow from the aquifer. Groundwater abstraction from the proposal is not expected to significantly impact the riparian and riverine and delta vegetation within the Millstream Wetlands given the riverine and delta vegetation requires a combination of sources to meet demand. Impacts to riverine and delta vegetation from a reduction to the springflow cannot be solely attributed to the proposal. Implementation of the proposal is not expected to result in significant impacts to flora and vegetation and it is expected that the EPA objective "*To protect flora and vegetation so that biological diversity and ecological integrity are maintained*" can be met.

Terrestrial Fauna	
EPA objective	The EPA Objective for this key environmental factor is to protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
Policy and Guidance	• Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023). • Environmental Factor Guideline - Terrestrial Fauna (EPA, 2016). • Technical Guidance - Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA, 2020). • *Biodiversity Conservation Act 2016* (BC Act). • *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

Potential impacts	• The proposal comprises the abstraction from existing production bores. No clearing of vegetation is required for this proposal and no direct impacts to terrestrial fauna and habitat are proposed.
	• Potential impacts to terrestrial fauna and habitat may include:
	    o Changes to the connectivity of pools may impact aquatic fauna habitat availability.
	    o Impacts to deep permanent pools as habitat for large bodied, long-lived fish species and water birds.
	    o Potential impacts to shallow macrophyte habitat inundated and available for macroinvertebrates, small-bodied fish and juveniles of large-bodied fish.
	• Changes in salinity have the potential to impact fish and macroinvertebrates directly through physiological stress and indirectly through loss of macrophyte habitat.

Mitigation	**Avoid**
	
	Groundwater abstraction from the Millstream aquifer cannot be totally avoided due to the requirement to maintain an essential public water supply and the current absence of alternative supply options. Water Corporation are actively progressing other water supply options to minimise the reliance on the Millstream aquifer as a source for the WPWSS.
	
	Minimise
	
	• Abstraction of up to 6GL/a has been limited until 2032 with a contingency of up to 3GL/a until 2027. Should abstraction continue beyond these dates, it will be reduced in alignment with an updated sustainable yield assessment and subject to an assessment in accordance with the relevant statutory decision-making process.
	• Obtain and comply with approvals under, *Rights in Water and Irrigation Act 1914.*
	• Monitor groundwater levels and pool water levels in accordance with the WRMOS (Appendix B).
	• Undertake contingency actions outlined in WRMOS if criteria are breached. Contingency actions include:
	    o Increased monitoring and reporting.
	    o Implement supplementation plan.
	    o Undertake Scheme response, commence negotiations to take additional water from other sources (e.g. RTIO Bungaroo source).
	    o Critical response supplementation in accordance with targets set in WRMOS.
	    o Reduce take.

Outcomes	It is not expected for groundwater abstraction to significantly impact pool water levels and associated wetlands and fauna habitat as water supply to the pools is predominately sourced during the wet season as a result of tropical cyclones and lows. As such no significant impacts to habitat and terrestrial fauna associated with the pools and wetlands are expected as a result of implementation of the proposal and it is expected that the EPA objective “To protect terrestrial fauna so that biological diversity and ecological integrity are maintained” can be met.

Subterranean Fauna	
EPA objective	The EPA Objective for this key environmental factor is o protect subterranean fauna so that biological diversity and ecological integrity are maintained.
Policy and guidance	• Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023). • Environmental Factor Guideline - Subterranean Fauna (EPA, 2016) • Technical Guidance - Subterranean fauna surveys for environmental impact assessment (EPA, 2021) • Note the sampling program undertaken pre-dates the requirements outlined in the Technical Guidance - Subterranean fauna surveys for environmental impact assessment published in 2021
Potential Impacts	Subterranean fauna habitat may be directly impacted by a reduction in habitat as a result of the groundwater abstraction from the Millstream aquifer.

Mitigation	**Avoid**
	
	Groundwater abstraction from the Millstream aquifer cannot be totally avoided due to the requirement to maintain an essential public water supply and the current absence of alternative supply options. Water Corporation are actively progressing other water supply options to minimise the reliance on the Millstream aquifer as a source for the WPWSS.
	
	Minimise
	
	• Abstraction of up to 6GL/a has been limited until 2032 with a contingency of up to 3GL/a until 2027. Should abstraction continue beyond these dates, it will be reduced in alignment with an updated sustainable yield assessment and subject to an assessment in accordance with the relevant statutory decision-making process.
	• Obtain and comply with approvals under, *Rights in Water and Irrigation Act 1914.*
	• Mitigation management measures for the protection of saturated stygofauna habitat are presented in the WRMOS (Appendix B) with aquifer groundwater level criteria to support aquifer ecosystems determined by the Department of Water and Environmental Regulations (DWER).
	• Undertake contingency actions outlined in WRMOS if criteria are breached. Contingency actions include:
	  ○ Increased monitoring and reporting.
	  ○ Implement supplementation plan.
	  ○ Undertake Scheme response, commence negotiations to take additional water from other sources (e.g. RTIO Bungaroo source).
	  ○ Critical response supplementation in accordance with targets set in WRMOS.
	• Reduce take.

Outcomes	Implementation of the proposal is not expected to result in significant impact to stygofauna as the maximum allowable reduction in habitat is limited to 5% of the 33m available saturated habitat thickness, with abundant remaining habitat available for stygofauna. Habitat type is consistent across the aquifer with no specialised pockets. Implementation of the proposal is not expected to significantly impact subterranean fauna and it is expected that the EPA objective "*To protect subterranean fauna so that biological diversity and ecological integrity are maintained*" can be met.

Holistic Impact assessment

The proposal has the potential to indirectly impact the Millstream Wetlands by altering the volume of the springflow from the aquifer entering Millstream Wetlands pools and rivers. The lowering of the watertable also has the potential to impact stygofauna through habitat loss.

Potential impacts to pool and river levels within the Millstream Wetlands are not solely directly related to groundwater abstraction as a result of implementation of the proposal with any observed impacts most likely to be caused by dry climatic conditions and a period without a significant recharge event from a tropical cyclone. The pool water levels in Millstream aquifer are directly correlated to the Fortescue River flows with springflow from the Millstream aquifer being approximately16.3% of water source into the pools.

Previous abstraction volumes and monitoring data has shown groundwater abstraction volumes greater than 9GL/a (up to 16GL/a) showed impact at year 3 at Deep Reach and after year 1 at Chinderwarriner pools. These impacts are not expected given the proposal is for a lower ongoing abstraction volume and a temporary contingency period. All pool water levels recovered. No long-term significant impacts to pool water levels are expected as a result of implementation of the proposal.

Potential impact and observations on pool levels, vegetation and erosion within the Millstream Wetlands are primarily due to climatic conditions and not directly related to groundwater abstraction as a result of implementation of the proposal. Groundwater abstraction from the proposal is not expected to impact the pool and river levels within the Millstream Wetlands with any observed impacts likely to be caused by climatic conditions which are not attributable to the proposal.

No clearing is proposed and no direct impacts to the Millstream Wetlands are expected as a result of implementation of the proposal.

The maximum allowable reduction in stygofauna habitat, which represents a less than 5% reduction, is not considered significant given the extent of remaining suitable habitat remaining.

The proposal is not expected to result in significant impacts to the Millstream Wetlands and implementation of the proposal is expected to meet the EPA objectives.

Cumulative Impact assessment

The Millstream aquifer is fully allocated, with Water Corporation holding the major license for 9GL/a for public water supply. Other users have a combined allocation of 0.573GL/a. As other groundwater users are 6.37% of total allocation, abstraction from the Millstream Borefield is the key consideration in assessing cumulative impacts on groundwater and groundwater dependent values, while taking into consideration external pressures (such as climate change) and the dependence of potable water supply on the existing Borefield.

While implementation of the proposal has the potential to contribute to cumulative impacts through direct groundwater abstraction and indirect impacts to groundwater dependant values, previous monitoring has shown prolonged periods of groundwater abstraction over 9.5GL/a did not result in significant long-term impacts. Given the proposal is for temporary abstraction no greater than 9GL/a, this is considered more minor in magnitude and potential impacts are not to a level that would alter the likely environmental outcomes for groundwater and dependant values.

Climate change projections into the near future (2030) predict:

- Higher temperatures and increased evapotranspiration.
- Strong rainfall variability due to El Nino Southern Oscillation.

- Possible changes in rainfall patterns, but direction is uncertain.
- Increased intensity of extreme rainfall events.

Water Corporation's is planning planning for both wetter and drier futures using downscaled projections from the Bureau of Meteorology. For Harding Dam and Millstream aquifer:

- Eight sets of downscaled projections broken into three scenarios are used to assess ongoing near and medium-term risks to the supply systems.
- Two of the most extreme dry scenarios and two unprecedented dry scenarios (replicated from historical data sets), equitable to 10th and 40^{th} percentile rainfall, are used to assess the immediate short-term risk to Millstream aquifers triggers and criteria in order to inform the TWG's immediate adaptive management decisions.

Water Corporation considers the RiWI Act licencing process provides a comprehensive framework for accessing cumulative impacts. RiWI Act licensing decisions relating to the Millstream aquifer are guided by the Pilbara Groundwater Allocation Plan (2013), which considers cumulative impacts. In addition, the assessment of cumulative impacts is an inherent part of the RiWI Act licensing framework as it is a water allocation regime and sustainable water management is the primary goal. Any RiWI Act assessment of sustainability will take into account the impacts from other threatening processes and activities, such as climate change on recharge.

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1. Proposal

1.1 Proposal Content

Water Corporation (The Corporation) is an integrated water utility and the principal supplier of water services across Western Australia. The Corporation is owned by the State Government and is accountable to the Minister for Water for the delivery of water, wastewater and drainage services across 2.6 million square kilometres (km^2). The Corporation's purpose is '*to manage water services sustainably to make WA a great place to live and invest*.' Its services enable economic growth and prosperity for the community as well as protecting public health and the environment.

The Corporation is a well-established water service provider that maintains high levels of community and regulatory trust. The Corporation is also an experienced asset manager to ensure the delivery of safe, sustainable, reliable, compliant and cost-effective water services. The Corporation concurrently manages the State's water infrastructure to support population and economic growth.

The West Pilbara Water Supply Scheme (WPWSS or the Scheme) supplies the towns of Karratha, Wickham, Dampier, Roebourne, Point Samson and the industrial areas of Cape Lambert and the Burrup Peninsula. Water for the WPWSS is sourced from Harding Dam and Millstream Borefield (Millstream). The two sources operate in conjunction, with Harding Dam the primary source. Bungaroo Borefield is owned by Rio Tinto Iron Ore (RTIO) but supplies into the WPWSS to meet RTIO's demands under a water transfer agreement.

The proposal is to continue to abstract a total of up to 6 gigalitres per annum (GL/a) of groundwater until 2032, with an additional contingency of up to 3GL/a to 2027, from the Millstream aquifer as a secondary source for the Scheme. Groundwater abstraction beyond 2032 will be determined based on a sustainable yield assessment and the development of an alternative water source for the WPWSS, and assessed in accordance with the relevant statutory decision-making process.

The Corporation is expected to abstract up to 6GL/a from Millstream but requires an additional 3GL/a allocation for periods when supply from Harding Dam is not available. Harding Dam is treated as the primary source of water for WPWSS but may not be able to meet Scheme demand in the event of insufficient inflow. This inflow is required to provide sufficient water quantity and to ensure dam water quality that can be effectively treated by the water treatment plant. Millstream Borefield is used when there are water availability or water quality problems associated with Harding Dam. Recharge of Harding Dam and Millstream aquifer is variable and occurs largely through cyclonic events. Because of their proximity, both sources are often recharged by the same event or may concurrently experience a 'failed' wet season. As a result, Millstream Borefield may become the Scheme's only source, thereby requiring the additional 3GL/a as a contingency to 2027. Beyond 2027 an additional source will be required for the Scheme to maintain supply reliability and to meet future increase in demand until development of a new water source. Source augmentation options are discussed in Section 1.2.

The general proposal content description is presented in Table 1 and the proposal content elements in Table 2. The full Proposal Content Document is presented in Appendix A.

Table 1: General proposal content description

Proposal title	Abstraction of Groundwater from the Millstream aquifer
Proponent name	Water Corporation
Referrer name	Water Corporation
Short description	Water Corporation proposes to continue abstracting groundwater from the Millstream aquifer to supply WPWSS. The proposal is to continue groundwater abstraction from the Millstream aquifer up to 6GL/a until 2032 with a contingency of up to 3GL/a until 2027. The proposal allows for groundwater abstraction from Millstream Borefield as a secondary water source for the WPWSS.

Table 2: Proposal content elements

Proposal element	Location / description	Maximum extent, capacity or range
Physical elements		
Millstream Borefield	Figure 2	Production Bores PB1, PB2, PB3, PB4, PB5, PB6 - Crown Reserve 36991, Lot 55 Millstream Production Bores (unequipped) PB7, PB8, PB9, PB10, PB11, PB12 - Crown Reserve 36991, Lot 58 Millstream
Construction elements		
Not applicable – groundwater abstraction is currently occurring with established assets		
Operational elements		
Groundwater abstraction from the Millstream aquifer	Figure 2	Continue groundwater abstraction up to 6GL/a until 2032 with an additional contingency up to 3GL/a to 2027
Rehabilitation		
Not applicable – assets are in operation		
Commissioning		
Not applicable – assets are in operation		
Decommissioning		
The need and timing of the decommissioning of groundwater bores and associated infrastructure will be as confirmed as and when the long-term operation of the Millstream aquifer as a source for the WPWSS is defined.		
Other elements which affect extent of effects on the environment		
Proposal time*	Maximum project life	Abstraction up to 6GL/a until 2032, and up to 3GL/a contingency to 2027
	Construction phase	Not applicable
	Operations phase	See maximum project life
	Decommissioning phase	Not defined

1.2 Local and Regional Context

WPWSS supplies a population of approximately 22,000 (forecast to increase to 22,700 in 2025 financial year) in the towns of Karratha, Wickham, Dampier, Roebourne, Point Samson and the industrial areas of Cape Lambert and the Burrup Peninsula. In the 2023/24 financial year the Scheme had 8,787 residential connections and 1,792 non-residential connections. Major non-residential customers of the Scheme include Woodside Energy Group Ltd, Perdaman Chemicals and Fertilisers Pty Ltd and Pilbara Ports Authority. RTIO is another major non-residential customer but supplies its own demands in the WPWSS through the Corporation infrastructure from its own sources under a water transfer agreement. Figure 1 shows the location of the Scheme.

The West Pilbara region forecast demand is driven largely by industrial needs through the pipeline of major projects anticipated for key mining and energy organisations. Subsequently, the employment opportunity these major projects offer as part of the regional economic development, will attract an influx of permanent and temporary workforce populations, thus driving an additional residential demand. The current state of economic development and output in the City of Karratha is also largely driven by major mining and oil and gas projects that help to support 13,572 jobs in the region.

Significant investments in the region include Perdaman Urea, Woodside Scarborough Gas Project, Woodside and Yara Pilbara Fertilisers and investment in the Maitland Strategic Industrial Area. There is a $177 billion investment pipeline across the Pilbara, expected to foster significant economic expansion over the next decade. Significant investments include:

- Perdaman Urea Project, a $6B fertiliser manufacturing plant.
- Woodside's $12.2B Scarborough Gas Project via its Pluto Train 2 gas processing plant.
- Other major industry investments in the proposed Maitland Strategic Industrial Area with the propensity to attract temporary and permanent workforces and subsequently drive residential demand in the West Pilbara region.

The Perdaman and Woodside projects require significant amounts of water during their construction phase, and it is the WPWSS that has and will continue to supply to the potable water demand of these project camps. These projects require significant volumes in the near future in potable water supply for worker accommodation camps, which will consolidate to a smaller but still significant ongoing need during operations phase. As a result of these major projects, a temporary and permanent population influx would be attracted, resulting in growing residential demand. The residential and industrial demands if not met, may result in the state's overall economic output to be restricted.

Population growth of West Pilbara will be significantly constrained in the near future as the Corporation would not be able to accommodate water requests from major projects with associated impacts to population. Other major companies must rely on the WPWSS to meet their potable and non-potable water needs. While some projects may be able to self-source, this will not be an option to all given the cost and time effort involved. If such projects were to relocate to another State or country, WA's economic output and reputation may be impacted.

The need for the proposal provides water security, that would otherwise, jeopardise residential supply, industrial operations, and broader economic growth. The proposal is required to provide sufficient water to supply residents and industrial customers who are important contributors to State and National economies.

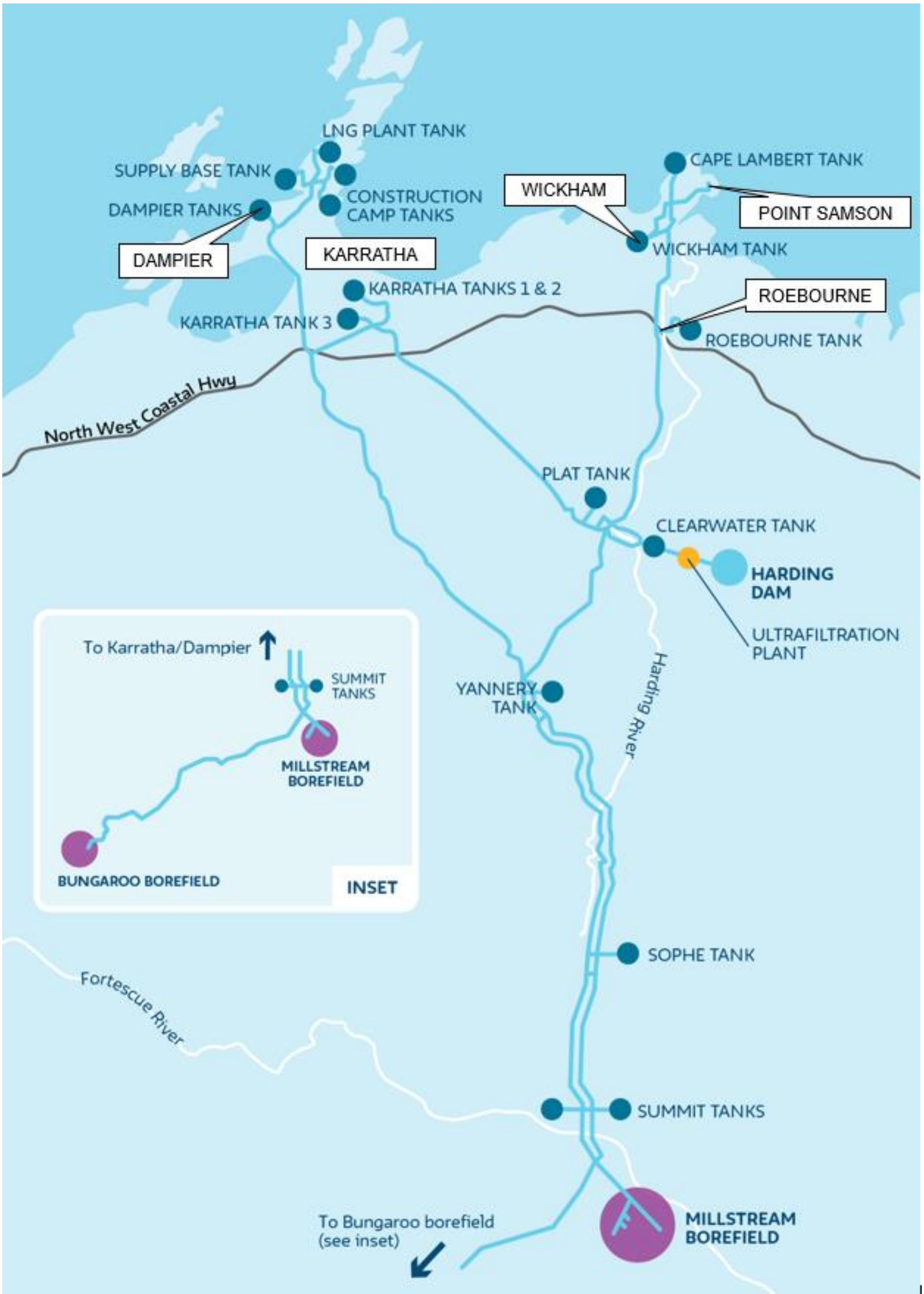


Figure 1: West Pilbara Water Supply Scheme (WPWSS)

Water for the WPWSS is sourced from Harding Dam and Millstream Borefield. The two sources operate in conjunction, with Harding Dam the primary source when water quality and quantity allow. The WPWSS is assessed and managed in accordance with the *Rights in Water and Irrigation Act 1914* (RiWI Act) and water for the Scheme is sourced under licence conditions stipulated by the Department of Water and Environmental Regulation (DWER). DWER has issued licences to take water under section 5C of the RiWI Act for the Scheme, with the current licences issued in 2022 and summarised in Table 5. Water is sourced from Millstream Borefield when use of Harding Dam is constrained and on an ongoing basis of up to 2GL/a in accordance with the conditions of these 5C licences.

Harding Dam, built in 1984 and used for water supply since late 1985, is located on the Harding River 28 km south-east of Roebourne. Its reservoir has a storage capacity of 63.8GL. Water is drawn from the reservoir and passes through a microfiltration water treatment plant before entering the Scheme's distribution system. Water treatment is required to achieve compliance with drinking water quality guidelines. Since commissioning of the plant in 2004, Harding Dam reservoir has provided the bulk of the Scheme supply. The Scheme is designed to operate with Harding Dam as the primary source with Millstream Borefield to be used when there are water availability or water quality problems associated with Harding Dam.

The Harding Dam project was referred to the Environmental Protection Authority (EPA) under section 55 of the (now repealed) *Environmental Protection Act 1972* in 1981. The EPA assessed the project in 1982 and recommended approval for the project to proceed in Bulletin 115 (Department of Conservation and Environment 1982). Harding Dam is not the subject of this referral as its approval pre-dates the current *Environmental Protection Act 1986* (EP Act).

The Millstream Borefield is located near the old Millstream Homestead, adjacent to the Fortescue River, about 130 km south of Roebourne. The borefield was established for public water-supply purposes in 1969. The borefield consists of six production bores, that draw water from an unconfined aquifer within the Millstream dolomite formation. A further six production bores (PB7 to PB12) are currently unequipped due to high salinity. Figure 3 shows a locality plan of the Millstream Borefield, within the Shire of Ashburton and located on the reserves:

- Crown Reserve 36991, Lot 55 Millstream (Bores PB1, PB2, PB3, PB4, PB5, PB6 Millstream Borefield).
- Crown Reserve 36991, Lot 58 Millstream (Bores PB7, PB8, PB9, PB10, PB11, PB12 Millstream Borefield).

Water is pumped from the Borefield, chlorinated, then transferred to two 9 megalitre (ML) summit tanks from where it gravitates into the distribution systems.

The Millstream aquifer (Ashburton-Hamersley-Millstream aquifer resource) is located around 100 km south of Karratha. The aquifer lies in the proclaimed Pilbara Groundwater Area and covers about 1,900 km^2. The aquifer holds a significant quantity of fresh water; the total storage for the Cainozoic sediments is estimated to be 1700GL based on a specific yield of 0.1. Table 3 shows storage estimates made by Barnett and Commander (1986) and reported in the Department of Water (DoW) Pilbara Groundwater Study (2009).

Table 3: Storage estimates for the Millstream aquifer Units (DoW, 2009)

Aquifer	Salinity (mg/l)	Area (km^2)	Storage (GL per km^2)	Storage (GL)
Millstream dolomite (unconfined)	<1000	250	1.5	375
Millstream dolomite (unconfined)	>1000	200	1.5	300
Millstream dolomite (confined)	<1000	450	1.5	675
Millstream dolomite (confined)	>1000	50	1.5	75
Robe pisolite	<1000	150	1.0	150
Kumina conglomerate (Weelamurra)	<1000	120	1.0	120
Kumina conglomerate (Weelamurra)	>1000	60	1.0	60

Abstraction volume from the Millstream Borefield is driven by a combination of the proportion of demand unmet by Harding Dam, how much water is being transferred from the Bungaroo connection, the total capacity of the Millstream transfer main, maintenance schedules, refuelling, monitoring, and the individual and joint flow capacity of the production bores.

Figure 6 shows the historical abstraction volumes from the Millstream aquifer by the Corporation. Groundwater abstraction has exceeded 6GL/a during 1972-1985, 1988, 2000-2003, 2012, 2014-2016. Groundwater abstraction exceeded 9GL/a 1978-1984, 2001-2003 and 2012.

The Millstream area, most of which is within the Millstream Chichester National Park, is of environmental, social and cultural importance. The National Park was established to protect and maintain areas of significant value. The natural pools and surrounding riverine ecosystems at Millstream Wetlands rely on groundwater discharge from the Millstream aquifer and intermittent seasonal flow from the Fortescue River. The system occupies a broad ancestral valley between the Hamersley Range in the south and the Chichester Range in the north and is crossed by the Fortescue River.

To minimise the impacts on the ecosystems, the Corporation currently operates and monitors the Scheme (both Millstream Borefield and Harding Dam) in accordance with DWER approved Water Resource Management Operation Strategy (WRMOS) (Appendix B). The Millstream area is jointly managed by DWER, the Department of Biodiversity, Conservation and Attractions (DBCA), Yindjibarndi Aboriginal Corporation (YAC) and the Corporation.

RTIO established a new groundwater source at Bungaroo Creek in 2014 to meet RTIO water demands. The Bungaroo Borefield abstracts from a different aquifer to Millstream. The Corporation has an agreement with RTIO to accept approximately 8GL/a of Bungaroo water into the Scheme at Millstream and transfer that water to RTIO’s demand centres. The borefield is owned and operated by RTIO and the Corporation does not report on the Bungaroo Borefield under the RiWI Act.

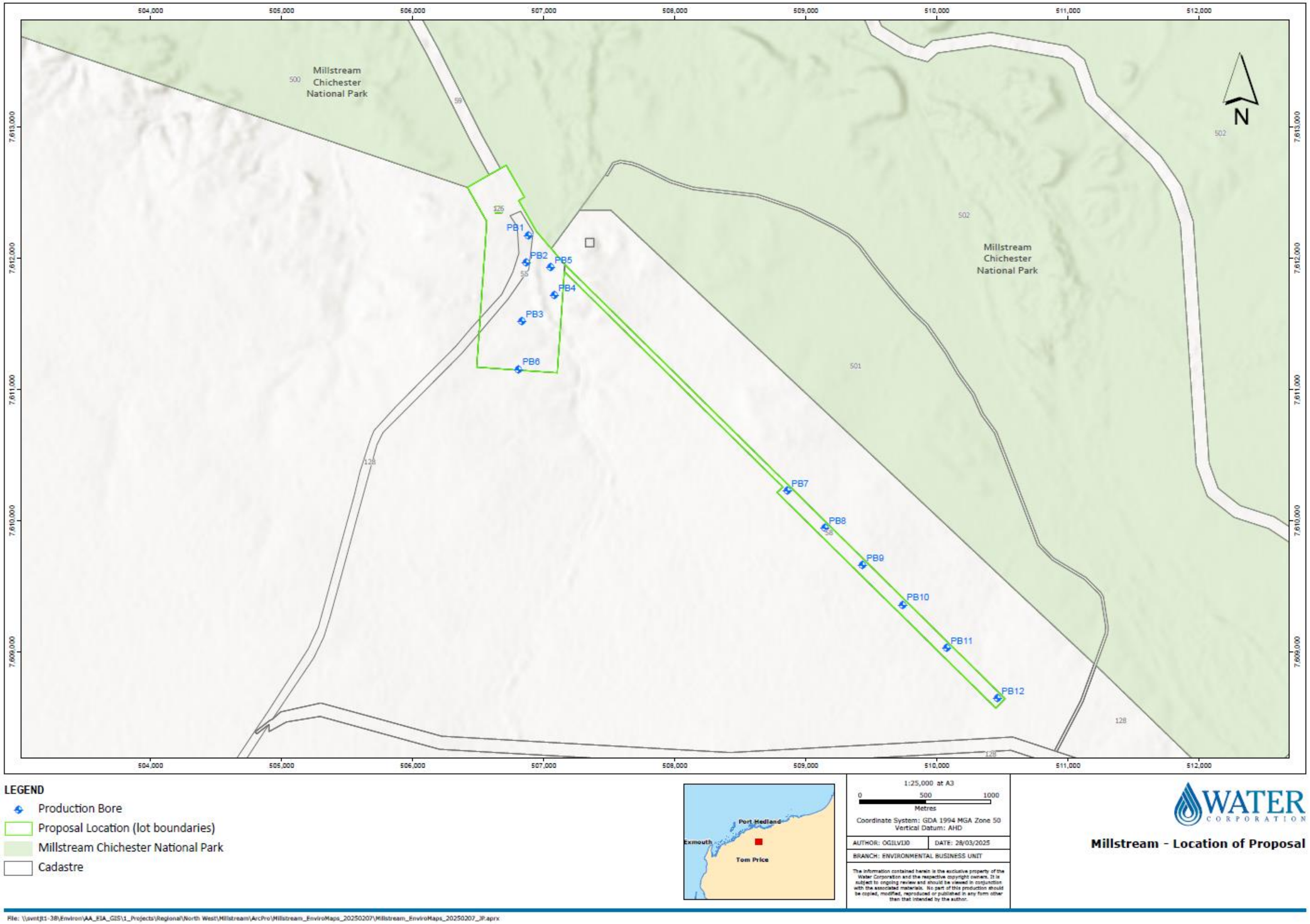


Figure 2: Millstream Borefield

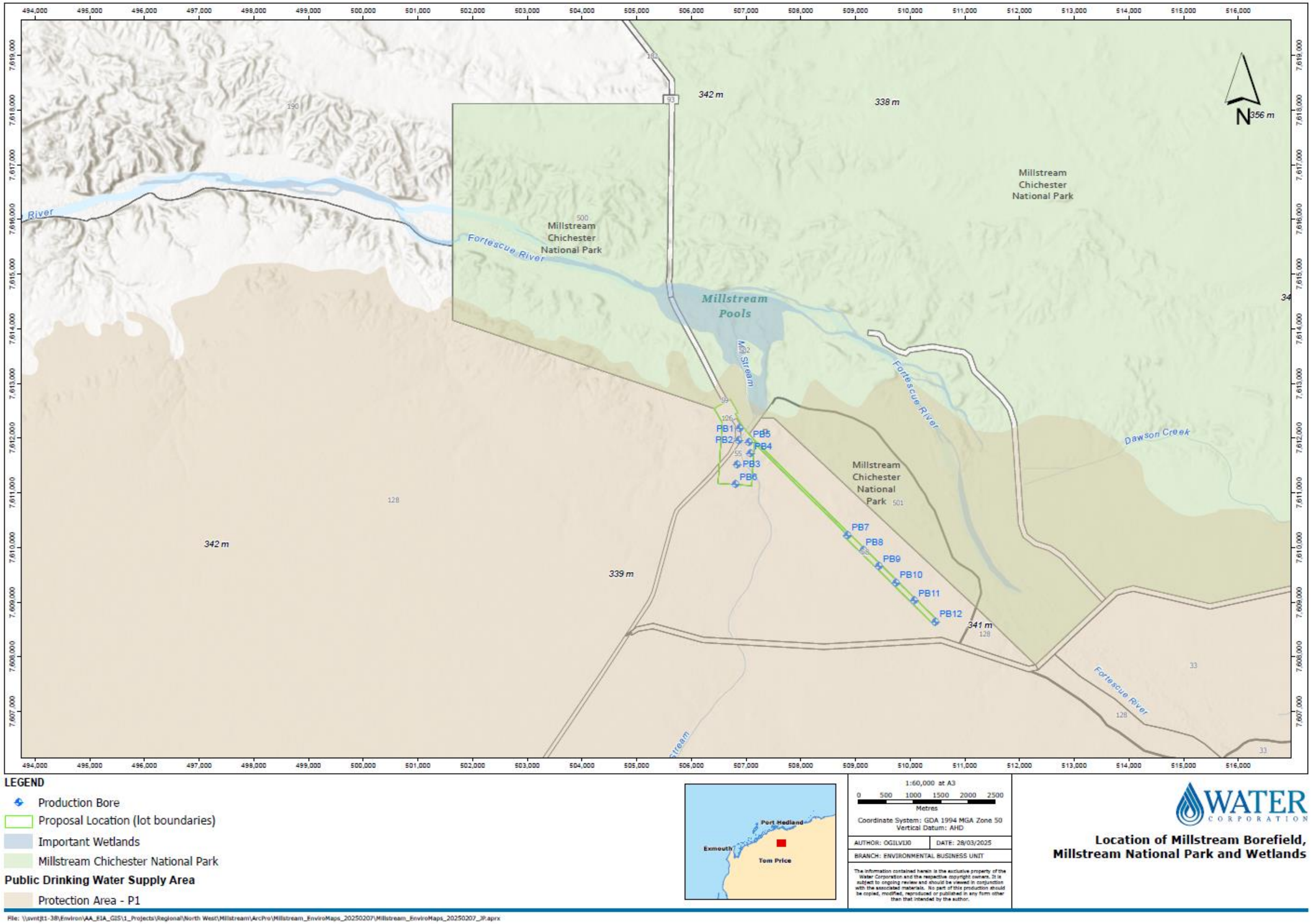


Figure 3: Location of Millstream Borefield, Millstream National Park and Wetlands

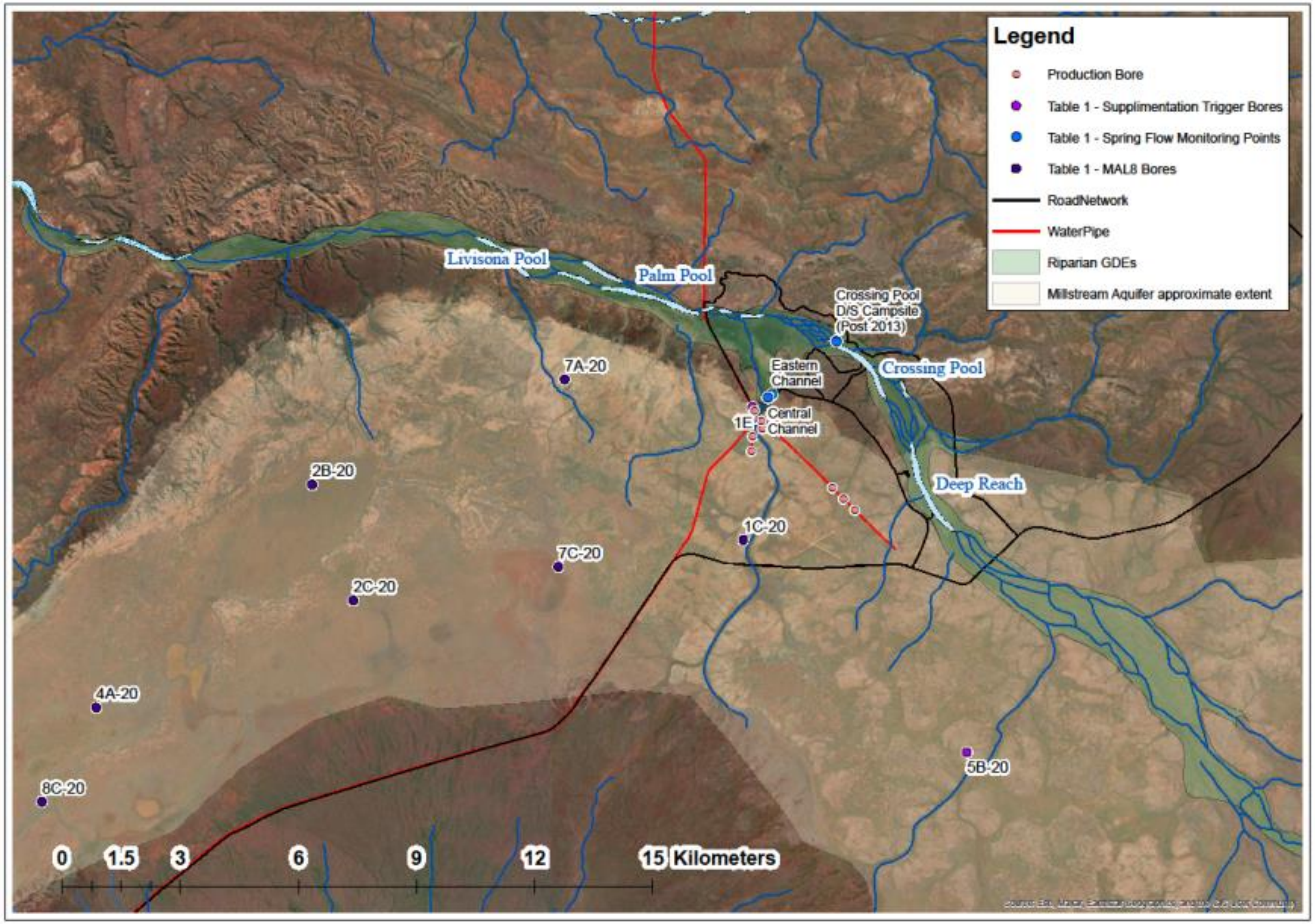


Figure 4: Millstream aquifer – Springflow and Mean Aquifer Level Trigger and Criteria Monitoring Locations (Table 1 Sites in TWG Report representing Table 11 in 2020 WRMOS addendum plus Table 13 in 2014 WRMOS)

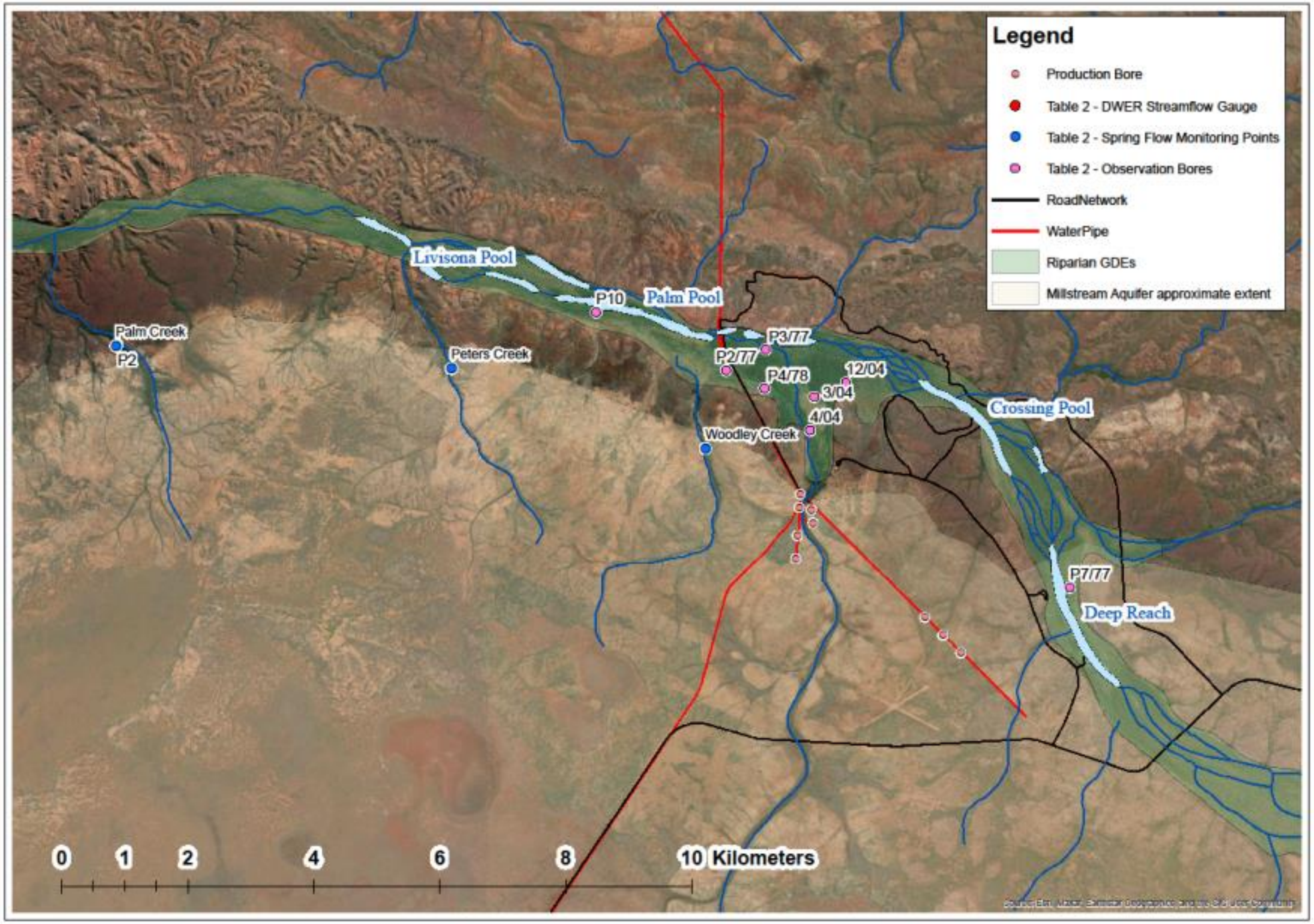


Figure 5: Millstream aquifer – Other Springflow, Riverine and Delta observation sites (Table 2 sites in the TWG Report representing Table 14 in the 2014 WRMOS)

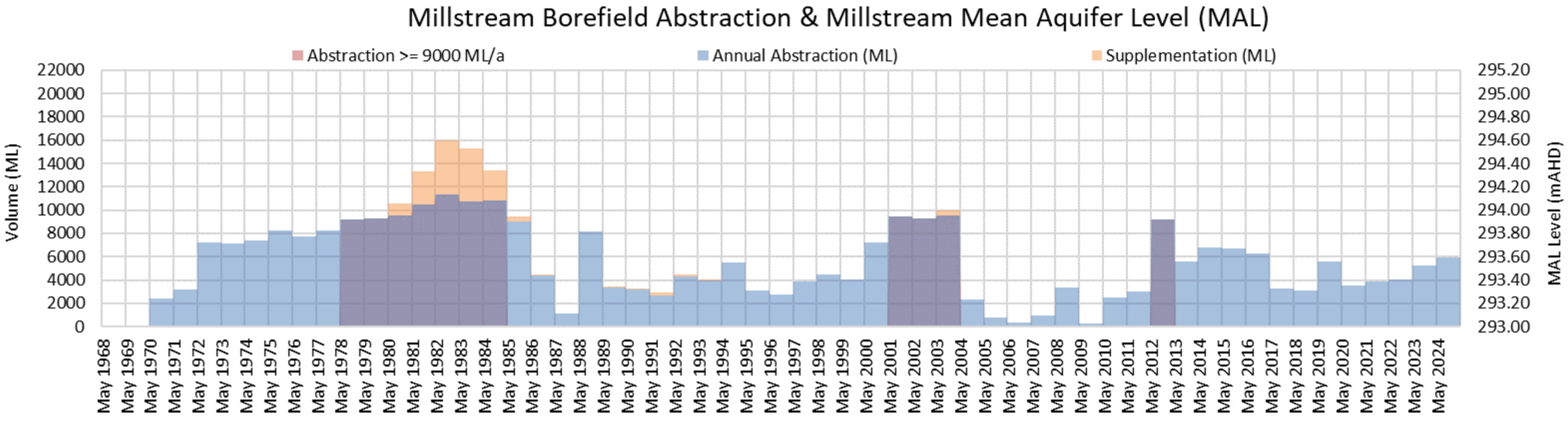


Figure 6: Historical groundwater abstraction volumes (based on May-April Water Year, 2024 values are YTD as of 1 April 2025).

1.3 Scheme Source Planning

To maintain water supply reliability for the Scheme and meet future demand, the Corporation has evaluated a number of source options and is currently undertaking investigations for a Seawater Desalination Plant (SDP) as the preferred solution to supplement supply from the current sources.

Early planning works identified potential SDP locations within the Burrup area, and engagement with the Murujuga Aboriginal Corporation (MAC) and other stakeholders is ongoing to confirm possible plant locations. The Corporation has also explored locations off the Burrup Peninsula.

The forecast delivery date for the proposed Water Corporation SDP is 2032. The ultimate and staged sizing of the plant is yet to be determined. To support a robust determination, the Corporation has confirmed funding for an independent reassessment of the aquifer sustainable yield. The Corporation's expectation is that the scope of this reassessment will be developed in collaboration with DWER and YAC.

In February 2025, the State Government announced that the Corporation would engage with RTIO on the feasibility of Stage 2 of RTIO's Dampier SDP being made available for an interim supply of 4GL/a to help meet demand requirements until a long-term additional source can be delivered. The forecast delivery date for Stage 2 of the RTIO SDP is 2027, however the timeframe for the associated integration works is still being defined. This would effectively replace the current temporary 3GL/a licence for Millstream once operational until the next source is built.

Further interim actions include the pursuit of a suite of upgrade works at the Harding water treatment plant and in the distribution system to maximise the use of Harding Dam when available to further reduce abstraction from Millstream Borefield. Those works will improve the daily production capacity of the plant and increase the ability to treat water when dam levels are low. The Corporation continues to implement demand management activities with customers. The Waterwise Towns program has been delivering water efficiency activities in West Pilbara for six years. This year's program is underway and includes:

- Providing 'Showerhead Swap' in the City of Karratha to save water in homes.
- Delivering a series of four comparative water use behaviour change letters to 4000 residents in West Pilbara.
- Collaboration with major employers and property managers in Karratha to provide tenants with information on fixing leaks and sprinkler compliance.
- Engagement with high water users under the Water Efficiency Management Plan, offering audits if needed.
- Reviewing and providing plumbing and irrigation services to high-use non-residential sites, including professional leak detection.
- Use of smart meters and data loggers to promptly detect and repair leaks through customer notifications.

Water carting is not considered feasible due to the large volume of water required to meet demand and distance and availability from alternative sources.

The activities planned to be undertaken, to enable a staged reduction in groundwater abstraction while still meeting demand until the delivery of a new, alternative water source for the Scheme, are outlined in Table 4.

Table 4: Summary of the proposed source development activities from 2022 until 2032:

Time frame	Annual groundwater allocation	Key activities and alternative source options
2022	15GL/a reduced to 9GL/a comprising base 6GL/a allocation temporary 3GL/a allocation.	• Allocation for Millstream Borefield groundwater licence (GWL 105696) reduced from 15GL/a to the current 6GL/a licence. • Separate temporary groundwater licence (GWL 205069) for 3GL/a issued for five-year period until 2027, to enable a staged reduction in abstraction while still meeting demand until the delivery of a new, alternative water source for the Scheme.
2025	9GL/a comprising base 6GL/a allocation temporary 3GL/a allocation.	• Response to YAC third-party referral of Millstream Borefield and proposal to manage under RiWI Act. • Ongoing implementation of demand management activities (i.e. Waterwise Towns program). • Commitment to investigate distribution and drawdown of production bores, including resampling and assessing of bores 7 to 12. • Commenced suite of upgrade works at Harding Dam water treatment plant and in the distribution system to maximise use of Harding. Works include improvements in daily production capacity and an increased ability to treat water when dam levels are low. Business case currently being submitted to State Treasury to expedite delivery. • Commission independent review to reassess the sustainable yield in the absence of supplementation as a viable management option. The scope of that review to be developed in collaboration between the Corporation, DWER and YAC.
2026	9GL/a	• Completion of independent sustainable yield review.
2027	Potential allocation reduction to 6GL/a	• Expiry of temporary 3GL/a groundwater licence (GWL 205069) on 21 Feb 2027. • Potential availability of Stage 2 of RTIO Dampier SDP for interim supply of 4GL/a until the Corporation long term source can be delivered. Availability of this source option dependent upon feasibility work currently underway including source integration studies.
2032	Allocation volume set at redefined sustainable yield for the aquifer	• Forecast delivery of proposed Water Corporation SDP with an initial capacity of 5GL and future staged upgrades dependent upon the long-term yield available from Millstream as determined through the RiWI Act licencing process. Additional funding is required for the SDP with the first stage estimated to cost in the order of $500M.

On 11 November 2024 YAC submitted a third-party referral under section 38 of EP Act for the abstraction of 9GL/a from the Millstream Borefield. Within the referral, five actions were recommended to be implemented as alternatives to abstracting up to 9GL/a from the Millstream aquifer. As these actions relate to alternative supply options, they are listed below and addressed in turn:

1 Water restrictions on the WPWSS to curb usage.

2 Infrastructure investment to reduce leakage, and to improve the efficiency and capability of Harding Dam to supply at low dam levels.

3 Broader distribution of production bores at Millstream to mitigate pumping impacts.

4 Development of short to medium term alternate water resources until an SDP solution is delivered.

5 Immediate collaboration with RTIO to access 4GL/a of capacity at RTIO's Dampier SDP.

Water restrictions

The implementation of customer water restrictions is a management response available for all public supply schemes in Western Australia and the decision to do so rests with the State Minister for Water, following recommendation from the Corporation. Based on our current available information the application of restrictions on the WPWSS is expected to have negative consequences for the local community and industry, and consequently damaging reputational consequences for the Corporation and the State Government. This will include a degradation of the condition of residential gardens and public open space, and negative economic impacts for the irrigation, garden and nursery businesses in Karratha.

In an effort to test these assumptions the Corporation has commissioned the modelling of the vegetation response for the increased water restriction scenarios in the WPWSS (and other schemes) to assess the level of risk and determine if further restrictions could be implemented with specific timing to maximise water savings and minimise the negative consequences. This work will commence in April 2025 and is expected to be completed by the end of June 2025.

Water efficiency programs are already underway at multiple regional towns to target excessive water usage and encourage water wise behaviours.

System leakage and upgrades to the Harding water treatment plant

The Corporation has commenced work on a suite of works to further address water loss from the Scheme and to maximise the ability of Harding Dam to supply water thereby reducing the demand on the Millstream source. That suite of works is the focus of a $29.7M business case currently being submitted to the State Treasury to expedite the delivery of those works. If the funding is provided in financial year 2026, the proposed suite of works will include:

- A treatment membrane upgrade at Harding Dam water treatment plant to increase the daily production rate.
- Aeration at Karratha tanks to better manage disinfection by-products that typically constrain the use of Harding Dam at low storage levels.
- Customer digital meter replacement to facilitate demand management initiatives.
- Proactive asset renewal to minimise potential water loss.
- Waste water treatment plant upgrades to maximise the availability of reuse water for public open space in Karratha and reduce the use of potable water from the Millstream aquifer.
- Increased ecohydrological monitoring at Millstream to better assess the response of the aquifer system to climate and abstraction.

Broader distribution of production bores at Millstream

The current distribution of production bores is shown in Figure 4. Production is currently undertaken from production bores 1 to 6 that are all located within 1500m of one another. Production bores 7 to 12 are aligned in a linear fashion to the south-east and use from these bores has been progressively discontinued due to elevated salinity levels. Bores 7 and 8 were the last to be used and production ceased at those bores in 2015.

YAC and DWER have raised concern that the concentration of abstraction at bores 1 to 6 may be exacerbating the impacts of pumping on the aquifer system. To address this concern, the Corporation is currently assessing the drawdown impacts associated with different combinations of pumping rate and bore distribution. The Corporation has also committed to resampling and assessing the condition of bores 7 to 12 to guide a decision on whether these bores could be recommissioned; that work is currently being scheduled. The Corporation's intention is to share the results of these assessments with DWER and YAC as part of the current licence renewal process to facilitate the definition of the role of Millstream as a long-term source option for the WPWSS.

Short to medium-term alternate sources

The YAC referral describes Kumina Creek, Lower Fortescue River, Sholl Shear Zone, KT area and Harding Alluvials as alternate water sources that could be developed to augment the Scheme until a SDP solution can be delivered.

the Corporation has investigated the potential of a number of these locations and is of the view that:

- Several years would be required to make a high confidence assessment of the yield of these options sufficient to guide an investment decision and longer again to deliver the required infrastructure to connect to the Scheme. These would not provide an interim benefit, even if justified.
- The Corporation would still be relying on surface water sources and cyclonic events to recharge these sources.
- Licensing arrangements required by DWER would likely include criteria and triggers similar to the Millstream Borefield.

Consequently, these options have been eliminated as viable interim source options for the Scheme and the resourcing and investment is better focussed on assessing the preferred option for the SDP.

RTIO Dampier SDP

The Corporation is actively engaging with RTIO to confirm the feasibility of the proposed second stage of RTIO's Dampier SDP to provide 4GL/a to the Scheme for public water supply. RTIO do require the 4GL to be returned when the Corporation's next source comes online. This is due to the work underway by RTIO to cease abstraction from the Bungaroo aquifer into the near future.

2. Legislative Context

2.1 Environmental Impact Assessment Process

The EP Act is the primary legislation that regulates environmental impact assessment (EIA) in Western Australia (WA).

On 11 November 2024 YAC submitted a third-party referral (YAC referral: YAC, 2024) under section 38 of EP Act for the abstraction of 9GL/a from the Millstream Borefield. The third-party referral presents the groundwater abstraction from the Millstream Borefield as an increase to 9GL/a and provides a groundwater study which suggests the maximum yield of the aquifer should be no more than 4GL/a (YAC 2004). The Corporation is not proposing to increase abstraction, rather a continuation of abstraction from the Millstream Borefield at 6GL/a consistent with the RiWI Act licence and with a contingency of 3GL/a until 2027. The purpose of this document is to provide an accurate description of the proposal and an assessment of impacts on relevant key environmental factors.

The Corporation has reviewed the YAC referral and has addressed any general inconsistencies between this referral and the YAC referral and undertaken a hydrogeological assessment of the YAC referral (Appendix C).

The proposal to abstract groundwater from the Millstream aquifer has previously been subject to an EIA via the sustainable yield studies (DoW, 2010) and the Pilbara Groundwater Allocation Plan (2013) by the Department of Water (DoW) (now DWER) as part of its core accountability for the management of the State's groundwater aquifers assets. The allocation planning, issuing of groundwater licences and the ongoing management of the Millstream aquifer is based on the outcomes of this EIA undertaken to protect the environmental values of the receptors identified. The EIA undertaken has been comprehensive, scientifically robust and meets the requirements for the EPA to determine whether the proposal may have a significant effect on the environment. Further detail on the Millstream studies and staged EIA process is within Section 5.4.

Operating the proposal since 1969 has demonstrated that the impacts from groundwater abstraction on the Millstream Wetlands and pools do not have a significant effect on the environment and can be managed sustainably, providing a balance of beneficial use of the water resources between provision of drinking water to the West Pilbara and environmental values of the Millstream aquifer. The management of impacts will continue to be undertaken in accordance with the WRMOS (Appendix B) which is a co-authored document with DWER and has been developed using robust, scientific techniques and is regulated under the RiWI Act. The environmental trigger values, monitoring requirements and management measures in the WRMOS are based on the EIA undertaken by DoW as part of the Pilbara allocation planning.

The Corporation considers that potential impacts are not significant and have been adequately assessed under the RiWI Act. Any formal assessment under the EP Act would be a duplication of the assessment already undertaken by DWER under the RiWI Act.

The environmental impacts associated with the proposal are not so significant to warrant assessment under Part IV of the EP Act; due to:

- An EIA assessment has already been undertaken.
- Approvals have already been granted under the RiWI Act.
- The Corporation is planning for an alternative water supply option in approximately 2032.

- The ongoing compliance with existing environmental approvals are already in place.
- DWER is already the regulatory authority for management and compliance with The Corporation's existing RiWI Act approvals, which require operation and management of Millstream Borefield in accordance with the WRMOS.
- Section 38G(4) of the EP Act provides for the EPA to take into account other statutory decision-making processes that can mitigate potential impacts of the proposal on the environment, as undertaken by the RiWI Act mechanism.

This proposal is consistent with many other projects within the State that are well into the operational phase that were not referred under Part IV of the EP Act, but already regulated under other Acts. The Corporation has existing licences for groundwater abstraction at the Millstream Borefield under the RiWI Act with DWER. The Corporation considers the RiWI Act as a suitable assessment pathway for the proposal given that DWER are the authority for allocation planning, this application planning is scientifically robust, all allocation planning and strategy documents are publicly available and further engagement is undertaken in the Millstream Harding Consultative Committee and Technical Working Group, of which YAC is a member.

2.2 Rights in Water and Irrigation Act 1914

Within WA, DWER is responsible for determining the volume of groundwater that can be sustainably abstracted without compromising environmental values and for issuing water licences in accordance with the RiWI Act.

The WPWSS is assessed and managed in accordance with the RiWI Act and water for the Scheme is sourced under strict licence conditions stipulated by DWER. DWER has issued licences to take water under section 5C of the RiWI Act for the Scheme, with the current licences issued in 2022 and summarised in Table 5.

Table 5: Water Corporation's licences under the RiWI Act for WPWSS

Licence	Source	Entitlement	Expiry	Status
Surface Water Licence (SWL) 105715	Harding Dam	15GL/a	11 May 2024	Renewal under assessment by DWER
Groundwater Licence (GWL) 105696	Millstream Borefield	6GL/a	11 May 2024	Renewal under assessment by DWER
Temporary GWL 205069	Millstream Borefield	3GL/a	21 Feb 2027	Current

In 2022 the approved allocation for Millstream Borefield groundwater licence (GWL 105696) was reduced from 15GL/a to the current 6GL/a in accordance with DWER's sustainable yield and long-term reliable allocation assessment (DoW, 2010). A separate temporary groundwater licence (GWL 205069) for 3GL/a was also issued in 2022 for five-year period until 2027, to enable a staged reduction in groundwater abstraction while still meeting demand until the delivery of a new, alternative water source for the WPWSS.

The Corporation submitted licence renewals to DWER for SWL 105715 and GWL 105696 on 26 April 2024 before the expiry date of 11 May 2024. The renewals were for the same volumes previously licenced; 6GL/a from the Ashburton-Hamersley-Millstream resource (GWL 105696) and 15GL/a from Harding Dam (SWL 105715). The licence renewal applications are currently under assessment and the Corporation is in discussions with DWER on conditions associated with the renewals. In accordance with section 22 of Schedule 1 of the RiWI Act, the Corporation is operating the WPWSS under the current licences until the DWER assessment has been completed and new licences are issued.

The WRMOS (Appendix B) describes specific operation, monitoring and reporting requirements to be followed as a condition of the water allocation licences. The WRMOS aligns with the Pilbara Groundwater Allocation Plan (2013), which recognises Millstream's high ecological, social and cultural value and requires Harding Dam to be used as the primary water source for the WPWSS. This approach is consistent with the EPA's approval of Harding Dam, which recommended that Millstream aquifer only be used if water quantity or quality issues are experienced at the Dam (Department of Conservation and Environment 1982).

Recharge of both the Harding Dam and Millstream aquifer is variable and occurs largely through cyclonic events. Because of their close proximity, both sources are often recharged by the same event or may concurrently experience a 'failed' wet season. As a result, Millstream Borefield may become the Scheme's only source when the aquifer has experienced a long period of no recharge and declining groundwater levels.

The Pilbara Groundwater Allocation Plan (DoW, 2013) outlines water abstraction rules that have been developed to minimise the impacts on the ecosystem. The plan sets out Millstream aquifer environmental water requirements (EWRs), variable criteria (that account for a range of water availability conditions) and the steps that need to be taken each year by the Corporation to determine management responses including the level of monitoring. The requirements are reflected in the WRMOS and adherence is a licence condition for both the Harding Dam and Millstream licences.

The requirements of the WRMOS can be summarised as:

- DWER determines the recharge class for the current year based on previous wet season flow data.
- Trigger and criteria values corresponding to recharge class are specified for:
  - Deep Reach pool, Chinderwarriner pool outflows and groundwater levels at bores 1E and 5B to maintain Millstream Wetlands.
  - Mean Aquifer Level (MAL) to maintain aquifer groundwater levels and support riparian vegetation.
  - Deep Reach pool and Chinderwarriner pool outflows and groundwater levels to support riverine and delta vegetation.
- The implementation of a monitoring program and management responses are required if trigger or criteria levels are reached in the pools and monitoring bores.

Since the WRMOS was approved in 2014:

- Triggers and criteria values have not been reached for MAL monitoring bores.
- Trigger values have been reached twice at Deep Reach.
- Springflow and Groundwater triggers values were reached, in January 2025 for Chinderwarriner pool.

For each of the three Groundwater Dependent Ecosystems (GDEs) in the Millstream System DWER have identified key hydrological relationships (hydro-ecological linkages) that the management criteria aim to maintain. The triggers set in the WRMOS warn of the potential for criteria to be breached and prompt a range of management responses. When triggers have been reached, the appropriate management responses as outlined in Table 15 of the WRMOS have been implemented as agreed by the Millstream Harding Technical Working Group (TWG).

These responses include increases to monitoring frequency, budgeting for vegetation monitoring increases to the frequency of reporting to the TWG, commencement of additional monitoring such as downstream flow observations at Livistona and spreading of abstraction across the borefield.

Prior to 2023 supplementation planning was also triggered but supplementation was not required following sufficient recharge to the aquifer.

Monitoring indicates that groundwater levels, springflow volumes, water quality levels and vegetation did not reach criteria and recovered in the proceeding periods following sufficient recharge to the aquifer.

In accordance with the WRMOS, summaries of compliance against the licence conditions are prepared annually and every fifth year requires a Water Monitoring Review (examining longer term impacts and compliance) to be provided to DWER. The most recent Water Monitoring Review was undertaken for the 2018-2021 period in October 2021 and is included in Appendix D.

The Corporation is currently preparing additional information for DWER to support the renewal of the licences. This information includes addressing YAC concerns raised in their referral to the EPA and in particular, how best to determine an appropriate long-term yield of the Millstream aquifer, defining appropriate management responses, and optimising the distribution of abstraction across the borefield.

3. Stakeholder Engagement

3.1 Key Stakeholders

Management of the Scheme is a collaborative undertaking, with the following key stakeholders involved in the joint management of the two sources via the Millstream Harding Consultative Committee (MHCC) and Millstream Harding Technical Working Group (TWG):

- Water Corporation – water services provider that operates and maintains infrastructure to ensure water supply reliability to the Scheme.
- Department of Water and Environmental Regulation (DWER) - regulatory agency that manages WA water resources for the benefit of present and future generations, in partnership with the community.
- Department of Biodiversity, Conservation and Attractions (DBCA) – agency that manages Millstream Chichester National Park, conserving native plants and animals and managing their sustainable use.
- Yindjibarndi Aboriginal Corporation (YAC) - Traditional Owner group representing Yindjibarndi people that develops, maintains and improves traditional connection with the surrounding land.
- Ngarluma Aboriginal Corporation (NAC) - Traditional Owner group representing Ngarluma people that develops, maintains and improves traditional connection with the surrounding land.

3.2 Stakeholder Engagement Process

The MHCC and TWG were established to jointly manage the Scheme sources to ensure that water dependant values are protected. As noted above, both MHCC and the TWG include representatives from the Corporation, DWER, DBCA and YAC.

MHCC meets annually and was established to provide strategic advice to DWER on management issues associated with Harding Dam and Millstream Borefield. The DWER Regional Manager chairs the meeting, and the DWER is responsible for organising the meeting and taking and distributing minutes.

A subgroup of the MHCC, the TWG comprises of operational and regional staff. TWG members are involved in the day-to-day operation, monitoring and management of Harding Dam and Millstream Borefield. The TWG meeting occurs quarterly, reporting to MHCC, as required in the WRMOS. Chairmanship moves between DWER and the Corporation every year (the Corporation took on chairmanship following the July 2024 MHCC meeting). Attendees are representatives from the Corporation, DWER, DBCA and YAC. YAC has been represented by employees of Yindjibarndi Water, Right Water Co. and RFF Australia. Representatives of the Ngarluma people are also invited but have not attended.

Monthly meetings with representatives from the Corporation, YAC and DWER were also established in December 2024 due to heightened interest in the performance of Millstream, Harding Dam and the WPWSS. It was agreed there would be a benefit in meeting regularly to discuss issues and advise of progress on actions. YAC is represented by employees of Yindjibarndi Water and Right Water Co.

Outside the MHCC and TWG, the Corporation engages with DBCA and YAC on project related matters in the Millstream area. The Corporation has met with YAC’s CEO on several occasions to discuss the WPWSS. In addition, the Corporation has engaged DWER Water regarding the RiWI Act licence renewals.

3.3 Stakeholder Consultation

A summary of stakeholder engagement with the Aboriginal Corporations and government departments from 2023 (with earlier key engagement events included), is provided in Table 6.

Table 6: Stakeholder consultation on activities related to Millstream Borefield

Stakeholder	Date	Issues/topics raised
TWG. Apologies YAC and NAC.	22 Jan 2020	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, erosion works, National Park updates and catchment and land management issues including dam catchment issues.
TWG. Apologies YAC and NAC.	20 May 2020	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, National Park updates and catchment and land management Issues including dam catchment issues.
TWG and Millstream Site Visit. Apologies YAC and NAC.	15 Jul 2020	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, the Corporation Supply Planning, National Park updates and establishment of cross agency communication protocols prior to visiting Millstream Park. Visit to erosion works and flow sites at Millstream.
TWG. Apologies NAC.	9 Sep 2020	WG meeting with DWER, DBCA, YAC and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, National Park updates and catchment and land management issues including dam catchment issues.
YAC.	22 Sep 2020	Ethnographic Report for Millstream Supplementation Bores and Millstream Redrill project.
MHCC. Apologies YAC and NAC.	4 Nov 2020	Annual MHCC meeting with DWER, DBCA and the Corporation. Discussion on outstanding action items, TWG Report, annual monitoring, WPWSS updates, Millstream aquifer model update, discussion on supplementation bore condition assessment, erosion mitigation works and National Park management.
TWG. Apologies YAC and NAC.	20 Jan 2021	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, National Park updates and catchment and land management issues including dam catchment issues.
WG. Apologies YAC and NAC.	17 Mar 2021	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, Millstream supplementation bore update, investigations into loggers on MAL bores and National Park updates.

Stakeholder	Date	Issues/topics raised
TWG and Millstream Site Visit. Apologies NAC.	19 May 2021	TWG meeting with DWER, DBCA, YAC and the Corporation. Welcome to Country by YAC, discussed outstanding actions, the Corporation abstraction and monitoring reporting, the Corporation Supply Planning, National Park updates, YAC updates and erosion mitigation works. Visit to supplementation bores and erosion mitigation worksite.
TWG. Apologies YAC and NAC.	21 Jul 2021	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, the Corporation Harding WTP Reliability Investigation and National Park updates
YAC.	29 Jul 2021	Meeting with YAC Board and Elders to discuss options regarding erosion to Deep Reach pool. Included discussion on groundwater abstraction from the Millstream aquifer in relation to climate change.
TWG. Apologies YAC and NAC.	22 Sep 2021	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting and National Park updates.
MHCC. Apologies YAC and NAC.	17 Nov 2021	Annual MHCC meeting with DWER, DBCA and the Corporation. Discussion on outstanding action items, TWG Report, annual monitoring, WPWSS updates, WPWSS Conjunctive Yield Modelling, Demand Prediction and Source Planning, erosion mitigation and National Park management.
TWG. Apologies YAC and NAC.	25 Jan 2022	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, Millstream 20 Series Bore Comparisons, Environmental Trigger and Criteria Projections and National Park updates.
TWG. Apologies YAC and NAC.	24 Mar 2022	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, Trigger and Criteria Projections and National Park updates.
TWG. Apologies YAC and NAC.	2 Jun 2022	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, the Corporation project approvals update, update on installation of loggers on MAL bores and National Park updates
TWG Millstream Site Visit, Apologies from NAC.	5 Aug 2022	Visit to Deep Reach erosion mitigation site, WC Deep Reach erosion mitigation long term concept proposal presentation and discussion, the Corporation reporting, abstraction from Millstream, Harding Dam, monitoring compliance and Millstream aquifer modelling update.

Stakeholder	Date	Issues/topics raised
TWG. Apologies YAC and NAC.	21 Sep 2022	TWG meeting with DWER, DBCA and the Corporation. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, Millstream aquifer modelling, progress on securing desalination site, GHD report on erosion mitigation options, Livistona monitoring options, the Corporation project approvals and National Park updates.
YAC.	9 Nov 2022	Traditional Owner Meeting at YAC Centre Roebourne to discuss access to Harding Dam catchment area. YAC requested information on Millstream allocation and abstraction figures.
MHCC. Apologies YAC and NAC.	14 Feb 2023	Annual MHCC meeting with DWER, DBCA and the Corporation. Discussion on outstanding action items, TWG Report, annual monitoring, WPWSS updates, discussion on erosion mitigation and National Park management.
TWG. Yindjibarndi Water represented YAC. RTIO. Apologies from NAC.	7 Jun 2023	TWG meeting with DWER, DBCA, YAC and the Corporation. RTIO also attended. Discussed outstanding actions, the Corporation abstraction and monitoring reporting, National Park and YAC updates, and RTIO's Livistona Palm study.
TWG. Yindjibarndi Water represented YAC. Apologies from NAC.	14 Sep 2023	TWG meeting with DWER, DBCA, YAC and the Corporation. Discussion on outstanding action items, abstraction and monitoring update, supplementation project approvals and National Park management updates.
YAC.	9 Nov 2023	Meeting in which YAC requested information on Millstream allocation and abstraction figures.
TWG. Yindjibarndi Water represented YAC. Apologies from NAC.	5 Dec 2023	TWG meeting with DWER, DBCA, YAC and the Corporation. Discussion on outstanding action items, abstraction and monitoring update, supplementation project approvals and National Park and YAC management updates.
YAC CEO.	19 Dec 2023	Meeting on YAC's preference to cease abstraction from Millstream due to the cultural significance and to discuss access to country.
Yindjibarndi Water representing YAC.	11 Mar 2024	Provision of last 20 years of compliance monitoring datasets: • Water levels of all monitoring bores within the Millstream region. • Abstraction data for the Millstream Borefield and Harding Dam. • Harding Dam level.

Stakeholder	Date	Issues/topics raised
MHCC. Yindjibarndi Water represented YAC. Apologies from NAC.	25 Mar 2024	Annual MHCC Meeting with DWER, DBCA, YAC and the Corporation. Meeting covered previous action items, TWG summary, annual monitoring review, decline projections, future source planning, YAC/NAC activities, park management and action response to Deep Reach triggers.
Yindjibarndi Water representing YAC.	04 Apr 2024	Provision of trigger and criteria modelling results March 2024 as presented to MHCC.
Yindjibarndi Water representing YAC.	23 April 2024	Provision of site co-ordinates for monitoring locations on Millstream aquifer on request from Yindjibarndi Water.
Yindjibarndi Water representing YAC.	1 May 2024	Provision of hydrogeological investigation and modelling reports for Millstream on request from Yindjibarndi Water.
Yindjibarndi Water representing YAC.	6 Jun 2024	Provision of historical monitoring results on request from Yindjibarndi Water.
YAC CEO.	Jun 2024	Meeting on finding a cost effective, reliable, and timely supply of water from the date of implementation of a reduction in groundwater allocation at Millstream Borefield and into the long-term.
Yindjibarndi Water representing YAC.	10-18 Jun 2024	Various email/phone requests for data. The Corporation proved range of historical data and information to assist Yindjibarndi Water Yield Assessment. • Annual abstraction volumes for Millstream Borefield back to 1969. • Corporate reports on investigations into alternative sources. • Historical water quality data Millstream aquifer monitoring and production bores.
TWG. Yindjibarndi Water represented YAC. Apologies from NAC.	18 Jul 2024	TWG site meeting. Undertook cultural immersion at Juluwarlu, followed by a visit to Millstream to view Deep Reach and other local pools. The meeting allowed for a knowledge share and increased understanding between parties.
TWG. Yindjibarndi Water represented YAC. Apologies from NAC.	19 Jul 2024	TWG meeting with DBCA, DWER, YAC and the Corporation. Discussed monitoring, erosion remediation works, future vegetation surveys and increased reporting frequency.
Yindjibarndi Water representing YAC.	1-13 Aug 2024	Various email/phone requests for data. The Corporation proved range of historical data and information to assist Yindjibarndi Water Yield Assessment. • Climate projection summaries. • Harding Dam abstraction and dam level since 1985. • Monitoring data from 1970 onwards. • Millstream aquifer bore construction logs.
YAC CEO.	11 Aug 2024	Meeting on the Corporation’s commitment towards finding a cost effective, reliable, and timely supply of water for the Scheme into the long-term.

Stakeholder	Date	Issues/topics raised
DWER Water.	21 Oct 2024	Meeting to discuss licence renewal. DWER provided feedback on the draft WRMOS and advised they are reviewing Yindjibarndi Water's Millstream Groundwater Study September 2024 report. DWER planned to provide feedback in writing.
TWG. Yindjibarndi Water represented YAC. Apologies from NAC.	11 Nov 2024	TWG meeting with DBCA, DWER, YAC and the Corporation. Discussed abstraction, monitoring, maintenance and remediation works and future vegetation surveys.
DWER Water.	29 Nov 2024	Meeting with DWER Director General and Water Corp CEO on interpretation of WPWSS licence triggers and criteria for supplementation.
DWER Water.	2 Dec 2024	Meeting to clarify aspects of DWER's request for information to support the renewal applications.
Yindjibarndi Water representing YAC.	5 Dec 2024	Provision of digital Millstream lithological and bore construction details in CSV format on request from Yindjibarndi Water.
Yindjibarndi Water representing YAC.	6 Dec 2024	Provision of November 2024 monitoring results in advance of monthly YAC, DWER and the Corporation meeting.
Yindjibarndi Water representing YAC.	11 Dec 2024	Provision of Trigger and Criteria projection presentation to DWER and the Corporation meeting.
EPA.	16 Dec 2024	Acknowledgement of Millstream third-party referral during the Corporation and EPA chair engagement meeting.
Yindjibarndi Water representing YAC.	6 Jan 2025	Field visit and discussion on monitoring being undertaken. Recommendations provided by Yindjibarndi Water, which the Corporation currently reviewing.
DWER Water.	29 Jan 2025	Meeting to discuss DWER's request for information to support the renewal applications.
Yindjibarndi Water representing YAC.	11 Feb 2025	Provision of January 2025 monitoring results in advance of monthly YAC, DWER and the Corporation meeting.
EPA.	19 Feb 2025	The Corporation provided update to EPA on the response to the third-party referral of abstraction of groundwater from Millstream. Discussed key environmental factors, RiWI Act process, climate change impacts, future abstraction and long-term source planning.
TWG. Apologies from NAC.	5 Mar 2025	TWG meeting with DBCA, DWER, YAC and the Corporation. Discussed abstraction, monitoring, maintenance, and remediation works and future vegetation surveys.
Yindjibarndi Water representing YAC, DWER, The Corporation.	11 Mar 2025	Field visit and discussion on monitoring being undertaken. Visit to production bores, monitoring bores 1E, 5B, Peters Creek and Woodley Creek.

4. Environmental Principles and Factors

4.1 Principles

The object of the EP Act is “to protect the environment of the State, having regard to the following principles”. Table 7 presents the how the proposal has considered the principles of the EP Act.

Table 7: Object and principles of the EP Act

Principle	Consideration
1. The precautionary principle. Where there are threats of serious or irreversible damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation. In application of this precautionary principle, decisions should be guided by: • careful evaluation to avoid, where practicable, serious or irreversible damage to the environment; and • assessment of the risk-weighted consequences of various options.	The proposal to abstract groundwater from the Millstream aquifer has previously been subject to an EIA by then DoW as part of its core accountability for the management of the State’s groundwater aquifers assets and issuing groundwater licences based on the outcomes of these assessments. The EIA undertaken has been comprehensive, scientifically robust and meets the requirements for the EPA to determine whether the proposal may have a significant effect on the environment. The borefield has been in operation since 1969. During this time, DoW and the Corporation has developed an understanding on how the groundwater abstraction affects the Millstream aquifer and Wetlands, and the management measures required for any mitigation responses. This has led to the refinement of trigger values and management responses which are outlined in the WRMOS (Appendix B).
2. The principle of intergenerational equity. The present generation should ensure that the health, diversity and productivity of the environment is maintained and enhanced for the benefit of future generations.	The Millstream aquifer is currently being managed sustainability to ensure its continued use for water supply. The Corporation is actively planning and working towards other water supply options to minimise the reliance on Millstream as a major source to the WPWSS.
3. The principle of the conservation of biological diversity and ecological integrity. Conservation of biological diversity and ecological integrity should be a fundamental consideration.	The monitoring requirements, trigger values and management measures outlined in the WRMOS are targeted to minimise and abate impacts to the Millstream Wetlands, its vegetation and associated fauna habitat.
4. Principles relating to improved valuation, pricing, and incentive mechanisms. • Environmental factors should be included in the valuation of assets and services. • The polluter pays principles – those who generate pollution and waste should bear the cost of containment, avoidance and abatement.	The Corporation supplies the public with the State’s supply of drinking water. The Corporation operates under the *Water Corporation Act 1996*, with the function of providing water services, and with functions necessary for and related to that purpose, and for connected purposes. The Corporation connects people to water, building an appreciation for our valuable resource.

Principle	Consideration
• The users of goods and services should pay prices based on the full life-cycle costs of providing goods and services, including the use of natural resources and assets and the ultimate disposal of any waste. • Environmental goals, having been established, should be pursued in the most cost-effective way, by establishing incentive structure, including market mechanisms, which enable those best placed to maximise benefits and/or minimise costs to develop their own solution and responses to environmental problems	
5. The principle of waste minimisation. All reasonable and practicable measures should be taken to minimise the generation of waste and its discharge into the environment.	The proposal will take all reasonable and practical measures to minimise the generation of waste. No waste is expected to be produced by the proposal, with all groundwater abstraction to be fed into the WPWSS.

4.2 Key Environmental Factors

The key environmental factors for the proposal are:

- Inland Waters
- Social Surroundings
- Flora and Vegetation
- Terrestrial Fauna
- Subterranean Fauna

Table 8 outlines the EPA policies and guidance for each key environmental factor and the proposal has considered these policies and guidance, and why other environmental factors are not considered key environmental factors for the proposal.

Table 8: Policy and guidance

Environmental Factor	EPA policy and guidance	How the EPA policy and guidance has been considered
Key Environmental Factors		

Environmental Factor	EPA policy and guidance	How the EPA policy and guidance has been considered
Key Environmental Factor *Inland Waters*	Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023). Environmental Factor Guideline - Inland Waters (EPA, 2018).	This EIA considers inland waters as a key environmental factor based on the potential for significant impact to the environment and concludes the EPA objective for Inland Waters has been met. This EIA: • identifies inland waters as a key environmental factor and presents the EPA objective for this factor. • describes how this factor links with flora and vegetation, terrestrial fauna, subterranean fauna and social surroundings factors. The Corporation has reviewed the EIA considerations for this factor, as listed in the Environmental Factor Guideline - Inland Waters (EPA, 2018): • outlines the environmental values that may be potentially impacted by the proposal. • identifies proposal activities that may potentially impact the environmental values for inland waters. • presents the studies and supporting information to assess the significance of potential impacts on the environmental values identified for inland waters. • outlines whether the residual impacts are considered significant impacts and the EPA objective has been met.
	Inland Waters of the Pilbara, Western Australia (Part 1). Environmental Protection Authority Technical Series No 10. January 1988 (EPA, 1988). A Directory of Important Wetlands in Australia Third Edition (Environmental Australia, 2001).	EIA reviewed this guidance to identify the environmental values for inland waters.
	Antao, M. 2013, Pilbara monitoring program to support the Pilbara groundwater allocation plan, Department of Water, Government of Western Australia.	Monitoring has been undertaken in accordance with this guidance.
Key Environmental Factor *Social Surroundings*	Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023).	This EIA considers social surroundings as a key environmental factor based on the potential for significant impact to the environment and concludes the EPA objective for social surroundings has been met. This EIA:

Environmental Factor	EPA policy and guidance	How the EPA policy and guidance has been considered
	Environmental Factor Guideline - Social Surroundings (EPA, 2023). EPA (2023) Technical Guidance Environmental impact assessment of Social Surroundings – Aboriginal cultural heritage.	• identifies social surroundings as a key environmental factor and presents the EPA objective for this factor. • describes how this factor links with inland waters, flora and vegetation and terrestrial fauna factors. The Corporation has reviewed the EIA considerations for this factor, as listed in the Environmental Factor Guideline - Social Surroundings (EPA, 2023). • outlines the environmental values that may be potentially impacted by the proposal. • identifies proposal activities that may potentially impact the environmental values for social surroundings. • presents the supporting information to identify the likelihood for potential impacts on the environmental values identified for social surroundings. • outlines whether the residual impacts are considered significant impacts and the EPA objective has been met. • outlines how potential impacts to heritage places and cultural values can be managed under the *Aboriginal Heritage Act 1972* (AH Act).
Key Environmental Factor *Flora and Vegetation*	Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023). Environmental Factor Guideline - Flora and Vegetation (EPA, 2016).	This EIA considers flora and vegetation as a key environmental factor based on the potential for significant impact to the environment and concludes the EPA objective for flora and vegetation has been met. This EIA: • identifies flora and vegetation as a key environmental factor and presents the EPA objective for this factor. • describes how this factor links with inland waters, terrestrial fauna and social surroundings factors. The Corporation has reviewed the EIA considerations for this factor, as listed in the Environmental Factor Guideline - Flora and Vegetation (EPA, 2016): • outlines the environmental values that may be potentially impacted by the proposal. • identifies proposal activities that may potentially impact the environmental values for flora and vegetation. • presents the studies and supporting information to assess the significance of potential impacts on the environmental values identified for flora and vegetation.

Environmental Factor	EPA policy and guidance	How the EPA policy and guidance has been considered
		• outlines whether the residual impacts are considered significant impacts and the EPA objective has been met.
	Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016).	This EIA discusses the timing of the EIA previously undertaken for the proposal, as being after the publishing of the Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment by the EPA in 2016.
	Approach to vegetation monitoring in the Pilbara – guidance for proponents (DoW, 2013). Approach to vegetation monitoring in the Pilbara – guidance for proponents (DoW, 2024) (updated).	Monitoring has been undertaken in accordance with these guidelines.
Key Environmental Factor *Terrestrial Fauna*	Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023). Environmental Factor Guideline - Terrestrial Fauna (EPA, 2016).	This EIA considers terrestrial fauna as a key environmental factor based on the potential for significant impact to the environment and concludes the EPA objective for terrestrial fauna has been met. This EIA: • identifies terrestrial fauna as a key environmental factor and presents the EPA objective for this factor. • describes how this factor links with inland waters, flora and vegetation and social surroundings factors. The Corporation has reviewed the EIA considerations for this factor, as listed in the Environmental Factor Guideline - Terrestrial Fauna (EPA, 2016): • outlines the environmental values that may be potentially impacted by the proposal. • identifies proposal activities that may potentially impact the environmental values for flora and vegetation. • presents the studies and supporting information to assess the significance of potential impacts on the environmental values identified for flora and vegetation. • outlines whether the residual impacts are considered significant impacts and the EPA objective has been met.
	Technical Guidance - Terrestrial vertebrate fauna surveys for environmental impact	This EIA discusses the timing of the EIA previously undertaken for the proposal, as being after the publishing of the Technical Guidance - Terrestrial

Environmental Factor	EPA policy and guidance	How the EPA policy and guidance has been considered
	assessment (EPA, 2020).	vertebrate fauna surveys for environmental impact assessment EPA in 2020.
Key Environmental Factor *Subterranean Fauna*	Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023). Environmental Factor Guideline - Subterranean Fauna (EPA, 2016).	This EIA considers subterranean fauna as a key environmental factor based on the potential for significant impact to the environment and concludes the EPA objective for subterranean fauna has been met. This EIA: • identifies subterranean fauna as a key environmental factor and presents the EPA objective for this factor. • describes how this factor links with inland waters factor. The Corporation has reviewed the EIA considerations for this factor, as listed in the Environmental Factor Guideline Subterranean Fauna (EPA, 2016): • outlines the environmental values that may be potentially impacted by the proposal. • identifies proposal activities that may potentially impact the habitat for subterranean fauna. • presents the studies and supporting information to assess the significance of potential impacts on the subterranean fauna and subterranean fauna habitat. • outlines whether the residual impacts are considered significant impacts and the EPA objective has been met.
	Technical Guidance - Subterranean fauna surveys for environmental impact assessment (EPA, 2021).	This EIA discusses the timing of the EIA previously undertaken for the proposal, as being after the publishing of the Technical Guidance - Subterranean fauna surveys for environmental impact assessment by EPA in 2021.
Other Environmental Factors		
Other Environmental Factor *Landforms*	Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023). Environmental Factor Guideline - Landforms (EPA, 2018).	The Corporation does not consider Landforms as a key environmental factor for assessment of the proposal, as the EIA for the Millstream Wetland and Millstream pools are assessed under the Inland Waters and Social Surroundings key environmental factors and riparian and wetland vegetation assessed under the Flora and Vegetation, Terrestrial Fauna and Social Surroundings key environmental factors. The EPA (2018) Environmental Factor Guideline: Landforms, outlines the definition of landforms, and how the landforms factor link with other environmental factors for the purposes of environmental impact assessment under Part IV of the EP Act. EPA defines landforms as: *The distinctive, recognisable physical features of the*

Environmental Factor	EPA policy and guidance	How the EPA policy and guidance has been considered
		earth's surface having a characteristic shape produced by natural processes. A landform is defined by the combination of its geology (composition) and morphology (form). The Guidelines lists examples of landforms, as banded iron formations, mesas, dunes and dune fields, caves and cave systems. Wetlands, pool and vegetation are not considered within the scope of the EPA key environmental factor for Landforms as they do not fit the examples provided and are not features that are intended to be assessed under this key environmental factor. The addition of Landforms as a key environmental factor is not appropriate for wetlands, pools and riparian and wetland vegetation and an EIA on these environmental values will be undertaken under the Inland Waters, Flora and Vegetation, Terrestrial Fauna and Social Surroundings key environmental factors.

Inland Waters is the primary key environmental factor for the proposal with the Millstream Wetlands (including pools) that may be potentially impacted by the proposal. The potential impacts to the Millstream Wetlands may subsequently potentially impact riparian and groundwater dependent vegetation (GDV), and fauna habitat associated with riparian and GDVs. Potential impacts to the Millstream Wetlands will also be assessed under the social surroundings key environmental factor, with the Millstream Wetlands and associated surrounding lands identified as cultural significant to Indigenous people and aesthetic (tourism) values from the Millstream National Park. The subterranean fauna environmental factor has been assessed due to groundwater abstraction within subterranean fauna habitat.

4.3 Mitigation Hierarchy

The mitigation hierarchy, as defined in the Statement of environmental principles, factors objectives and aims of EIA (EPA, 2023) has been applied for the proposal.

1. Avoid – Groundwater abstraction from the Millstream aquifer cannot be totally avoided due to the requirement to maintain an essential public water supply and the current absence of alternative supply options. The Corporation are actively progressing other water supply options to minimise the reliance on the Millstream aquifer as a source for the WPWSS.
2. Minimise – groundwater abstraction has been limited to up to 6GL/a until 2032 to align with the sustainable yield limit and the additional contingency of up to 3GL/a will be restricted to 2027 to mitigate potential long-term impacts to Millstream Wetlands and permanent pools.
3. Rehabilitate – groundwater abstraction has not resulted in drying of wetlands or permanent pools and no permanent drying is expected for the contingency period.
4. Offset – offsetting was not considered necessary given the abstraction yield was determined to be sustainable and therefore the proposal is not considered to result in significant adverse environmental impacts requiring offsetting.

5. Inland Waters

5.1 EPA Environmental Factor and Objective

The objective for the EPA (2016) Environmental Factor Guideline for Inland Waters is:

To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected.

5.2 Relevant Legislation, Policy and Guidance

- Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023).
- Environmental Factor Guideline - Inland Waters (EPA, 2018).
- Inland Waters of the Pilbara, Western Australia (Part 1). Environmental Protection Authority Technical Series No 10. January 1900 (EPA, 1988).
- A Directory of Important Wetlands in Australia Third Edition (Environmental Australia, 2001).
- Antao, M. 2013, Pilbara monitoring program to support the Pilbara groundwater allocation plan, Department of Water, Government of Western Australia.
- *Rights in Water and Irrigation Act 1914.*

5.3 Receiving Environment

5.3.1 Climate

The Pilbara coast's climate is arid-tropical with low and variable annual rainfall. The long-term-average annual rainfall at Millstream is 366 mm (110-year) with totals ranging from 151 mm in 2003 to 899 mm in 1900. This large variability is due to the episodic nature of tropical cyclones, tropical lows or cyclone related events, which cross the area in the summer months between December and April (Charles et al, 2015). These events provide the majority of total rainfall (80 per cent). Winter rainfall may also occur in May or June due to the influence of larger cold fronts that dominate winter weather patterns in the southern half of the state (Charles et al, 2015). The driest months are September to November and the wettest January to March.

Temperature data for Pannawonica, the nearest representative site with data from 1972 to 2005, indicates January has generally been the hottest month with a mean maximum of 41.0ºC and a mean minimum of 27.7ºC. July is the coolest month with a mean maximum of 26.7ºC and a mean minimum of 24.6ºC.

Due to low rainfall and high temperatures, monthly evaporation greatly exceeds monthly rainfall for every month of the year. The average annual evaporation at Millstream since 1970 is in excess of 3080 mm.

The Fortescue-Millstream hydroclimate (i.e. the climatology of the variables influencing the hydrological cycle) is highly influenced by the natural climate variability. Cumulative deviation from the mean analysis, of the climatic and hydrological long-term trends within the Fortescue and Millstream systems (Figure 7 and Figure 8), illustrates the underlying natural variability with:

- 1976 to 1996 representing a much dryer period including the longest recorded (5 years) and second longest (3 years) hydrological droughts.

- 1997 to 2013 representing a much wetter period including five of the largest observed rainfall and riverflow events recorded since observations began in 1969.
- 2014 to 2024 generally reflecting a median climate trend with lower annual rainfall interspaced by the occasional dry year and lower levels of wet season discharge through the Fortescue River. During this period two hydrological droughts were experienced in 2015 to 2017 and 2018 to 2020.

The higher rainfall years are due to tropical cyclones (TC), with the exception of 2009 and 2022, as outlined below:

- 1973: TC Kerry
- 1975: TC Joan.
- 1984: TC Chloe.
- 1995: TC Bobby.
- 1999: TC Tiffany (January), TC John (December).
- 2000: TC Steve C3 (March), TC Rosita (April)
- 2004: TC Monty C4
- 2006: TC ClareC3 (January) followed by TC Emma C1 (February), TC Glenda C2 (March) (largest recorded recharge event).
- 2009: Tropical low floods large portion of Pilbara (second largest recharge, and localised 1/50 - 1/100-year rainfall event directly over Millstream aquifer).
- 2011: TC Bianca C4
- 2013: TC Christine C4
- 2020: TC Damien C3 and a tropical low.
- 2022: Southwest autumn storm.

Figure 8 shows the Fortescue River (Gregory George at Lower Fortescue) and watertable are both directly correlated to rainfall, with tropical cyclones and lows and the proceeding rainfall-runoff contributing to significant recharge events.

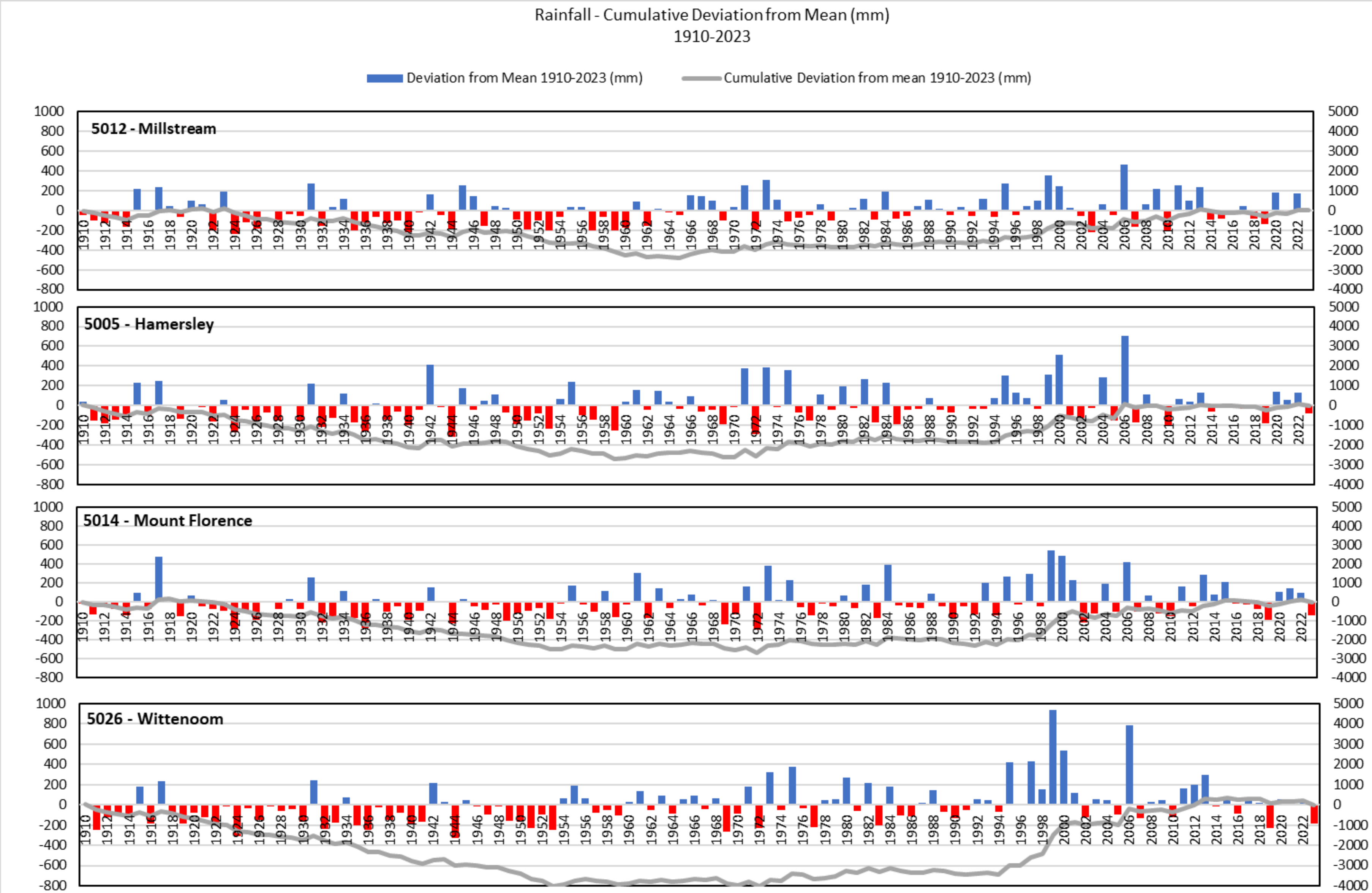


Figure 7: Rainfall Cumulative Deviation from Mean - Fortescue River Catchment

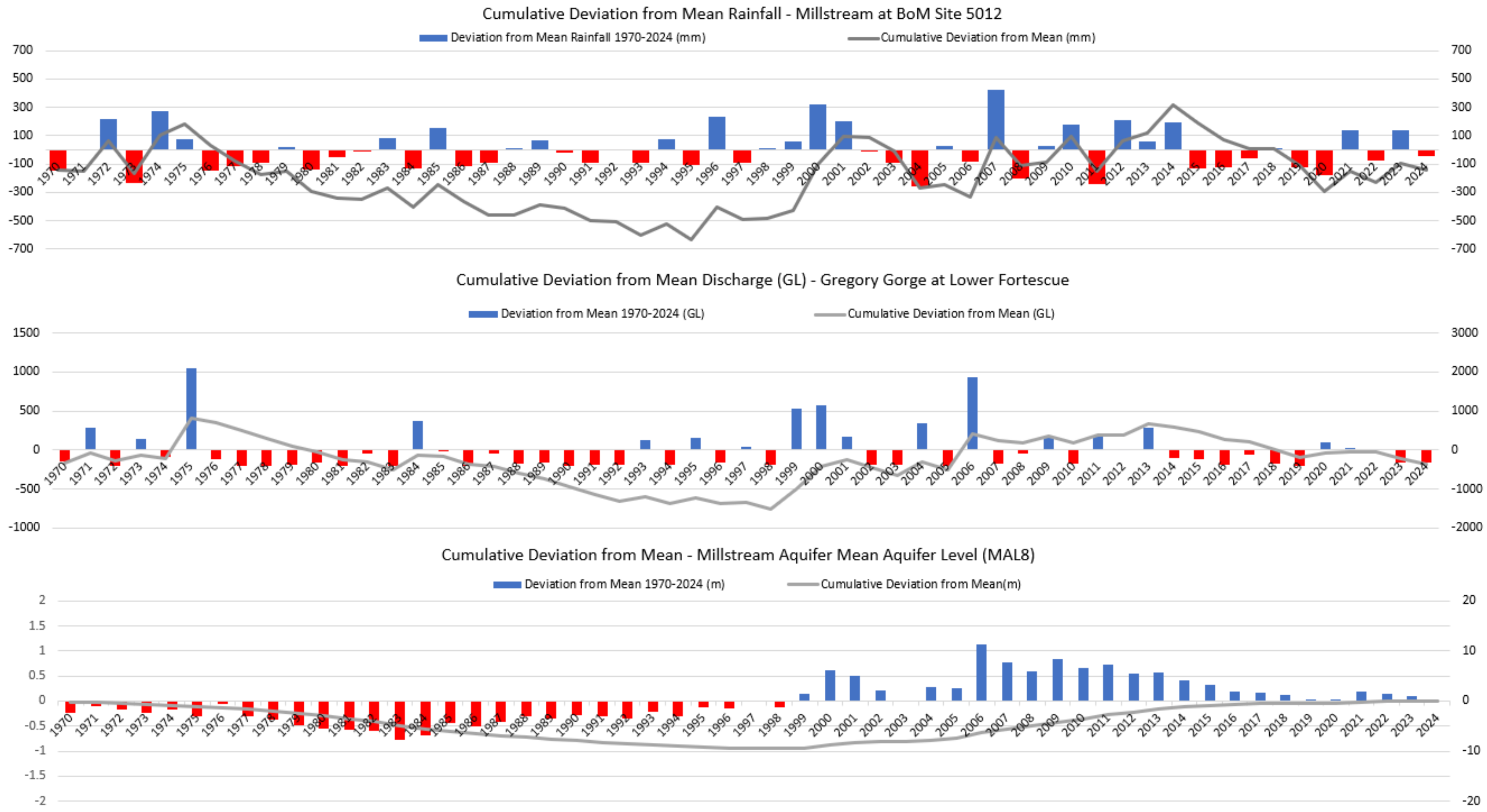


Figure 8: Cumulative Deviation from Mean - Millstream aquifer

5.3.2 Hydrogeology

The regional groundwater flow is from the south-east to north and the average annual fluctuation in water level is about 0.5 m (URS, 2007). To the east of Deep Reach pool, groundwater flows in the direction of the river while west of Deep Reach pool, the groundwater flow direction is predominantly south to north. Approximately 20km, to the south-west of Palm Creek, a ground water divide exists, beyond which the groundwater flows south-west towards Robe River.

Groundwater discharge supports the Millstream Wetlands and local riverine aquifers, formed from alluvial deposits of gravel. The riverine aquifers have a transmissivity of 14 to 110m2/d (Barnett and Commander, 1985). The primary groundwater discharge from the aquifer is around Deep Reach pool where the Fortescue River has cut directly into the dolomite and from the Millstream dolomite into Chinderwarriner pool. Much smaller quantities also discharge from Woodley Creek, Palm Creek, and Peters Creek where these creek systems have eroded into the edges of the dolomite formation.

Evapotranspiration is also considered to be a major discharge mechanism from the aquifer (McFarlane DJ (ed.), 2015) with rates of 550 to 3,700 mm per year (Welker Environmental Consultancy, 1998).

5.3.3 Hydrology

The Millstream Wetlands is listed in the Directory of Important Wetlands in Australia (Environment Australia, 2001). The Millstream Wetlands has been nominated for listing under the Ramsar Convention on Wetlands (DEC, 2007) but it is not currently listed as a Ramsar wetland as a Matter of National Environmental Significance (MNES) under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). The Millstream Wetlands include permanent and semi-permanent riverine pools and flowing streams. The key pools in the Millstream Wetland area are (Figure 9):

- Pools along the Fortescue River including Deep Reach, Crossing, Palm and Livistona pools.
- Off-channel pools and wetlands including Chinderwarriner pool, the Millstream Delta, Woodley Creek, Peters Creek and Palm Creek.

The pools and wetlands of the Millstream Wetlands are sustained by discharge through the Fortescue River predominately during the wet season (~ 85-95% of total annual flow by volume) and from the Millstream aquifer springflow all year round (~ 5-15% of total annual flow by volume).

The Fortescue River is characterised by the extreme range of flows, primarily as a result of tropical cyclones and lows. Flow within the Fortescue River occurs mostly between December and March after high rainfall events in the almost 14,000 km2 surface water catchment. The Fortescue Marsh forms the upper bounty of the contributing catchment, no flow has been recorded over/ past this barrier although it might be expected following very high rainfall events in the upstream catchment area (McFarlane DJ (ed.), 2015).

The topography of the river from the Fortescue Marsh to Gregory Gorge is very flat with a poorly defined main channel. In the lowest river section, from Gregory Gorge Gaging station (708002) to the coast, the stream channel is well-defined with a stream bed of coarse gravel (McFarlane DJ (ed.), 2015).

Average annual streamflow since monitoring commenced is 200GL. The maximum annual wet season flow, of 1,349GL, was recorded during the 1975-1976 wet season. This event was followed by a continuous flow period through the Gregory Gorge for a period of 11 months. The second highest wet season flow of 1,122GL, the result of significant rainfall across Millstream and the entire Fortescue catchment, resulted in the highest ever water level recorded within the Millstream aquifer. This event was followed by the longest recorded continuous flow period within the system. Lasting over 10 years, the uninterrupted flow through Gregory Gorge was sustained by additional significant wet season events in 2008-2009 and 2010-2011. A minimum wet season flow of 0.9GL was recorded in 1989-1990 coinciding with the longest hydrological drought ever recorded (1987 to 1992). Since 2015, average flow through the Gregory Gorge has been 115.8GL, 42% below the long-term average. During this period the lowest annual river flow since 1989 was recorded in 2019.

Millstream aquifer discharges as springflow into Deep Reach pool. The subsequent overflow from the pool and downstream flow along the Fortescue River sufficient to sustain the major permanent pools; Crossing, Palm and Livistona pools. The Millstream aquifer also discharges as springflow into Chinderwarriner pool, Palm, Peters and Woodley creeks, all of which are tributaries of the Fortescue River.

During the period 1970 to 1985, the average annual flow into the Millstream Wetland pools from the Fortescue observed at the downstream Gregory Gorge Gauging Station was 210GL/a. For this period the volume of springflow from the Millstream aquifer into Deep Reach pool was estimated at 11GL/a, Chinderwarriner pool was estimated at 3.8GL/a, and the combined input from the small springs west of Chinderwarriner pool (Woodley, Peters, and Palm Creeks) was estimated at 1.5GL/a (Barnett and Commander, 1985). Of the estimated 15GL/a discharged from the two main pools, 12GL/a was believed to be lost by evapotranspiration in the delta and along the riverbed. Springflows from the Millstream aquifer during this period represented 8% of total annual flow by volume recorded at Gregory Gorge with water sourced from the Fortescue River representing 92% of the total annual flow by volume. During this period the system was impacted by lower-than-average rainfall, a significant drought and high (up to 16GL/a) abstraction, influencing the estimates. As such it is not an accurate representation of the natural expected variation in the Millstream Wetland system. This period was removed during DWER's determination of Millstream's Environmental Water Requirements (EWR) and associated Environmental Water Provisions (EWP).

Figure 10 outlines the observed volumes of surface water flow between the pools over the past 10 years. The volume of surface water flow, observed at DWER's Gregory Gorge gauging station, is comprised of just over 84% rainfall-runoff via the Fortescue and almost 16% springflow contribution through Deep Reach and Chinderwarriner pools and Woodley, Peters and Palm Creeks. This demonstrates that the primary source of flow volume recorded at Gregory George continues to be from sources other than the Millstream aquifer. Of the identified springflow points, Woodley, Peters and Palm Creeks do not contribute significant volumes to the pools downstream of Deep Reach. Springflow, via Deep Reach and Chinderwarriner pools, supplies just over 15% of the average annual flow by volume, and maintains connectivity between the pools when the Fortescue River is not flowing.

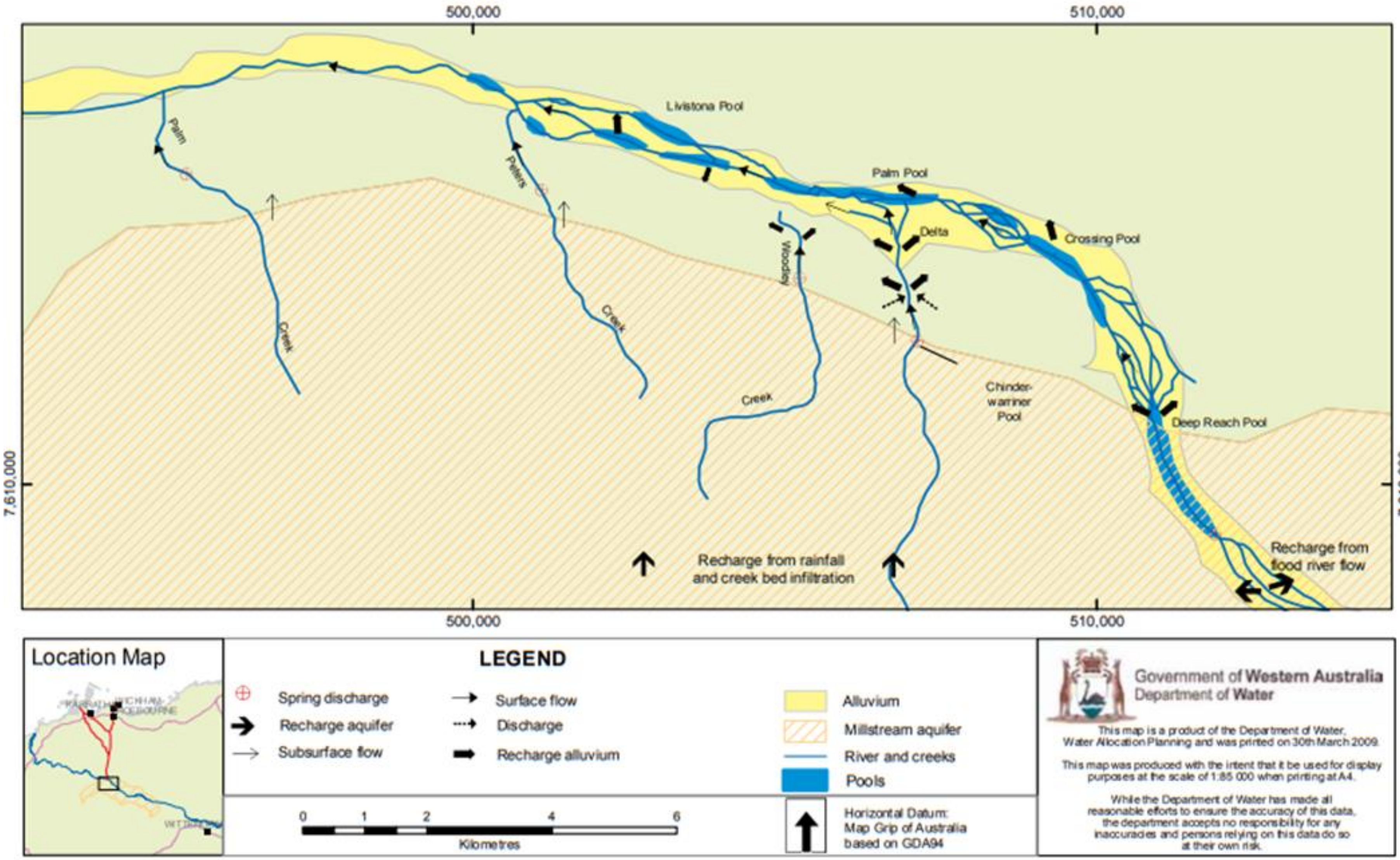
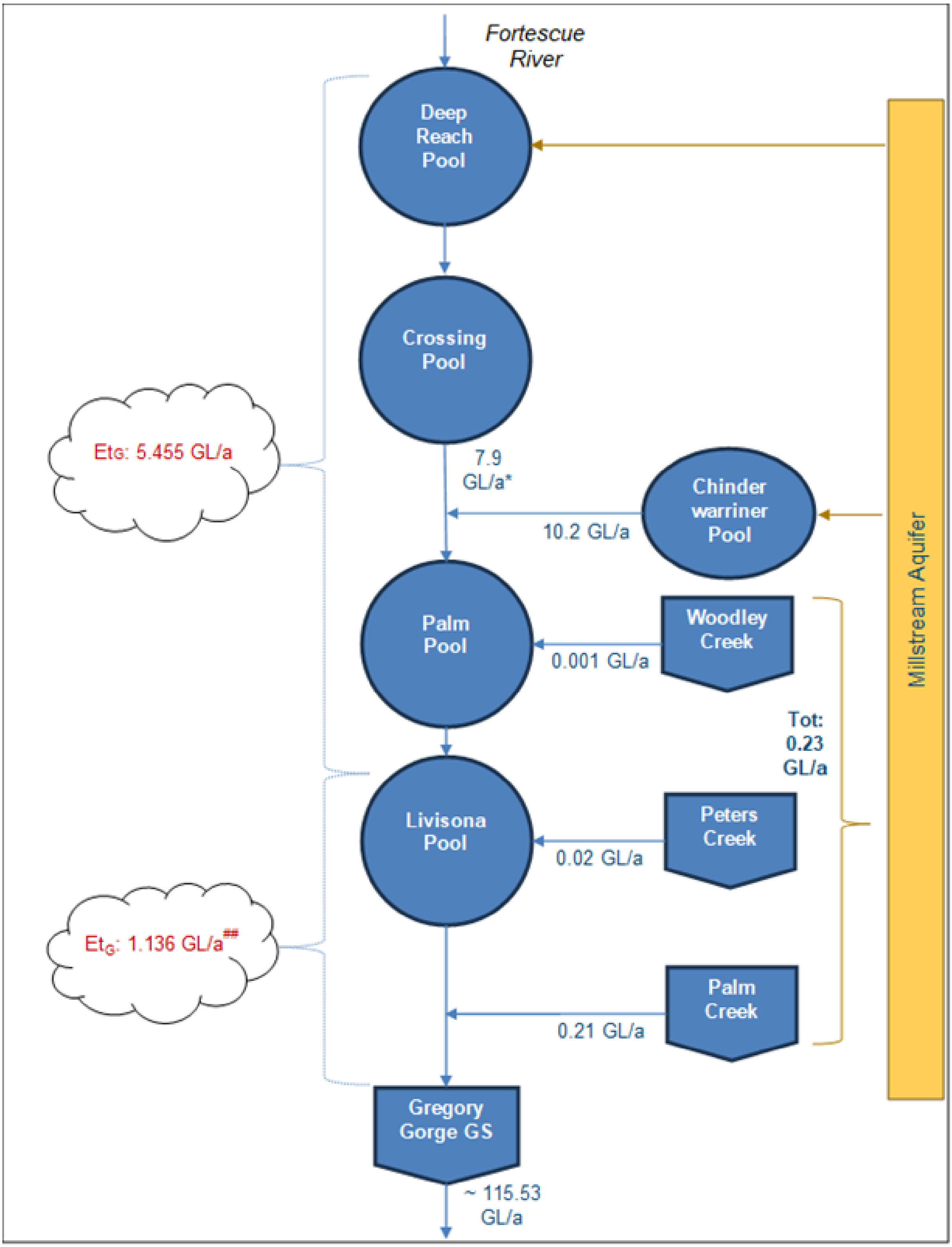


Figure 9: Hydrology of the Millstream aquifer showing recharge and discharge points and surface flow down the Fortescue River (Antao, M. and Braimbridge, M., 2009).



During dry and drought periods, ET_G is reduced through the physiological response of plants to reduced water availability (Eamus D, Hatton T et al. 2006; Merchant A, Callister A et al. 2007). Consequently, the evapotranspiration loss from Livistona to Gregory Gorge has been reduced to reflect the more frequent 3-month period of not flow observed under a dry water availability period.

DWER, 2019, unpublished

Figure 10: Average observed annual flow and estimated evapotranspiration demand 2014-2024 median period.

Recharge to the Millstream aquifer occurs in the following ways:

- Infiltration from flood flows in the Fortescue River (upstream of Deep Reach pool) with direct infiltration where the river intersects/passes over outcrops of the aquifer.
- Direct infiltration of rainfall across the unconfined parts of the aquifer.
- Infiltration from surface runoff into creeks (northern flank of Hamersley Range).
- Through flow from the flanking sediments.

Much of the recharge is attributed to flood events in the Fortescue River, with flows passing over outcrops of the aquifer and resulting in direct infiltration (Figure 11). The occurrence of flood events is closely correlated with observed recharge to the aquifer, as demonstrated by increases in the watertable (measured as MAL). The size and duration of river-flow events are both important factors in determining the magnitude of recharge to the aquifer. For example, the passing of cyclone Joan in 1975 resulted in the largest recorded river flow with peak flows of 3166 m3/s and a corresponding increase in MAL of 0.393 m. By comparison, smaller peak river flows between 100 m3/s and 1200 m3/s maintained over a longer period, such as those that occurred in 2006, resulted in an increase in MAL of approximately 1.0 m. Recharge to the aquifer from rainfall-runoff through the Fortescue has been estimated to range between less than 1 to 52GL/a.

Direct rainfall recharge to the aquifer was estimated to range from 3 to 16GL/a (Barnett and Commander, 1985) depending on rainfall location. In 2006 the combined rainfall from Tropical Cyclones Claire, Emma and Glenda is estimated to have resulted in 36GL of direct rainfall recharge into the aquifer.

5.4 Studies and Investigations

The proposal to abstract groundwater from the Millstream aquifer has previously been subject to an EIA by the DoW (now DWER) as part of its core accountability for the management of the State's groundwater aquifers assets and issuing groundwater licences based on the outcomes of these assessments. The allocation planning, issuing of licences and ongoing management of the Millstream aquifer is based on the outcomes of this EIA undertaken to protect the environmental values of the receptors identified. The EIA undertaken has been comprehensive, scientifically robust and meets the requirements for the EPA to determine whether the proposal may have a significant effect on the environment. The EIA undertaken by DoW was staged as outlined below:

- The receiving environment / baseline assessment on the environmental values was reported in:
  - Braimbridge, M, Antao, M and Loomes, R, 2010, Groundwater dependent ecosystems for Millstream: ecological values and issues, Environmental water report series, Report no. 13, Department of Water, Government of Western Australia, 2010.
  - Antao, M. and Braimbridge, M., 2009, *Millstream status report*, Department of Water, Government of Western Australia, Environmental water report no. 9. (Department of Water, 2009).
- An assessment on the potential impacts to the environmental values of the Millstream aquifer has been developed using robust, scientific techniques to inform a sustainable allocation planning of the Millstream aquifer. Identification of environmental values that may be impacted by the proposal, groundwater numerical modelling (SKM, 2009), existing monitoring data, risk assessments to determine impacts at different abstraction scenarios and determination of the sustainable groundwater abstraction rates to protect these environmental values are reported in:

- Braimbridge, M, Antao, M and Loomes, R, 2010, Groundwater dependent ecosystems for Millstream: ecological values and issues, Environmental water report series, Report no. 13, Department of Water, Government of Western Australia, 2010).
- Lower Fortescue groundwater allocation limit report. Method used to set an allocation limit and licensing rules for the Lower Fortescue alluvial aquifer. Water resource allocation and planning series Report no. 49 (Department of Water, January 2011).
- Pilbara Groundwater Allocation Plan 2013. Water resource allocation and planning report series Report no 55 (Department of Water, 2013).
- Management measures, monitoring programs, trigger values and other strategies to enable sustainable, continued operational abstraction, are reported in:
- Antao, M. 2013, Pilbara monitoring program to support the Pilbara groundwater allocation plan. Water resource allocation and planning report series October 2013 (Department of Water, 2013).

The environmental trigger values, monitoring requirements and management measures in the West Pilbara Management Operations Strategy (Appendix B).

A review of the impacts from historical abstraction from the Millstream aquifer is reported in:

- Haig, T 2009, The Pilbara coast water study, Department of Water, Hydrogeological record series, Report HG34, 183 p.

To address YAC concern about the 6GL/a safe yield determination and appropriateness of current management responses to criteria exceedances, the Corporation will commission an independent reassessment of the safe yield to guide the medium to long-term future of the aquifer as a source for the WPWSS. This assessment would effectively build on the foundational work done by DoW in 2010 and incorporate the monitoring data collected over the last 15 years and updated climate forecasting information.

5.5 Environmental Values

The Millstream Wetlands are a series of rivers, pools and wetlands and listed in the Directory of Important Wetlands (Environment Australia, 2001). The Millstream Wetlands include permanent and semi-permanent riverine pools and flowing streams, including:

- Pools along the Fortescue River including Deep Reach, Crossing, Palm and Livistona pools.
- Off-channel pools and wetlands including Chinderwarriner pool, the Millstream Delta, Woodley, Peters and Palm Creeks.

5.6 Potential Environmental Impacts

5.6.1 Direct

No clearing is proposed and no direct impacts to the Millstream Wetlands are expected as a result of implementation of the proposal.

5.6.2 Indirect

The Millstream Wetlands may be indirectly impacted by groundwater abstraction altering the volume of the springflow from the aquifer entering Millstream Wetlands pools and rivers.

Groundwater abstraction in the Millstream aquifer has the potential to contribute to the lowering the water levels in the Millstream Wetlands and permanent pools by reducing the volume of the springflow from the aquifer entering the pools. The pools in the Millstream Wetlands are not solely fed by groundwater, and there is not a direct connection between the pool levels and groundwater abstraction (refer to Figure 11, Figure 12 and Figure 13). There is a direct connection between pool water levels and surface water flow inputs, being the Fortescue River (roughly 80-90% by volume comes from the Fortescue) and influences such as evaporative losses. Any impacts observed in the pools may not be solely attributed to the proposal, and also, any breaches in trigger values may also not be directly attributable to the proposal.

Springflow, represented by the observed outflow from the pools and groundwater level monitoring in the Millstream aquifer monitoring is undertaken for Deep Reach and Chinderwarriner pools. These pools represent the greatest, by volume, springflow contribution from the Millstream aquifer and therefore the most suitable locations to determine impacts attributed from the proposal.

The monitoring at Deep Reach and Chinderwarriner pools assumes that conditions at these pools reflect the same conditions at downstream pools, such as Livistonia pool (refer to Figure 11, Figure 12 and Figure 13). Springflow and local groundwater level are also monitored to determine the additional contributions at Woodley, Peters and Palm Creeks into the system.

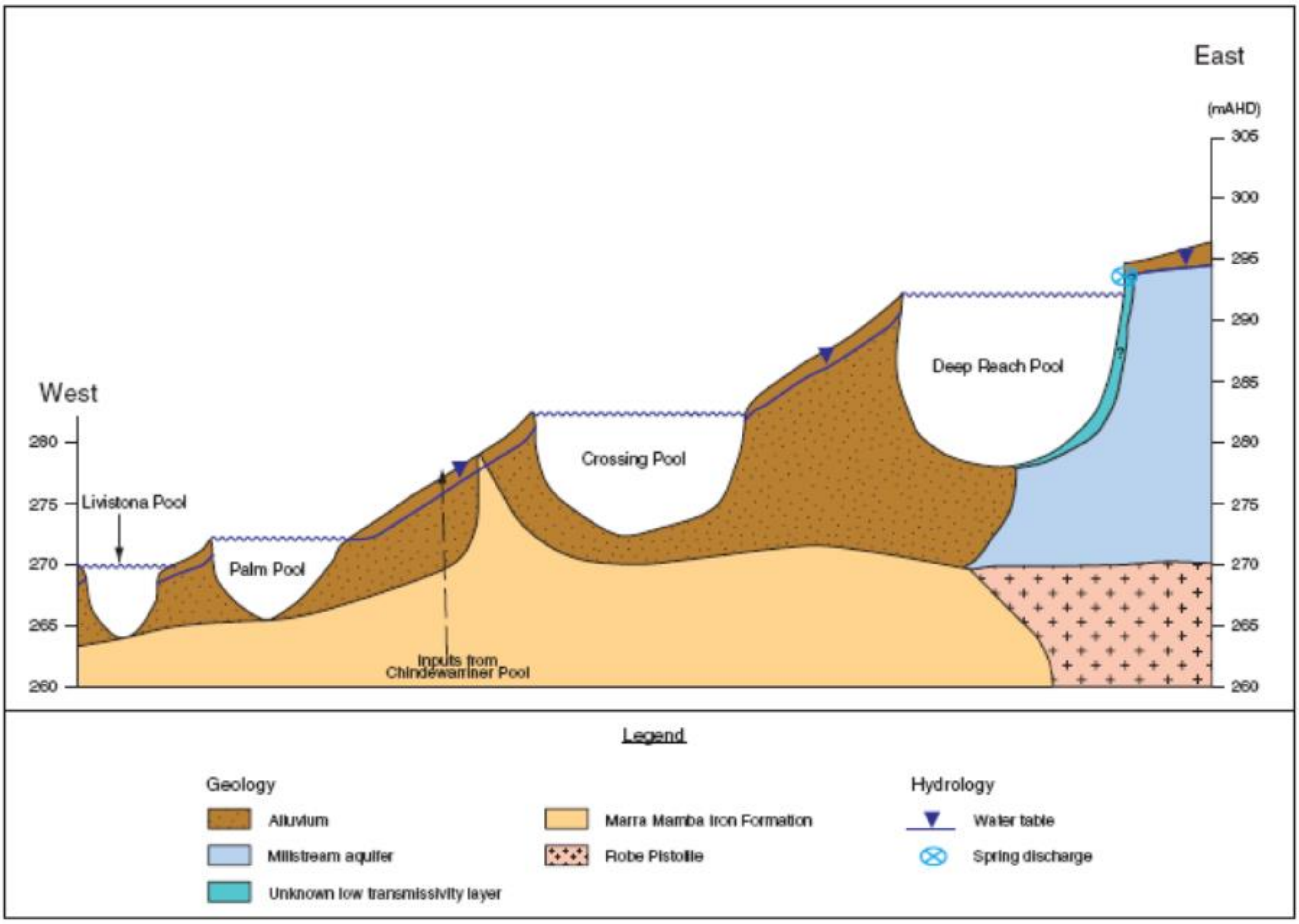


Figure 11: Longitudinal cross-section along the Fortescue River (revised from DEC 2007) (DoW, 2010)

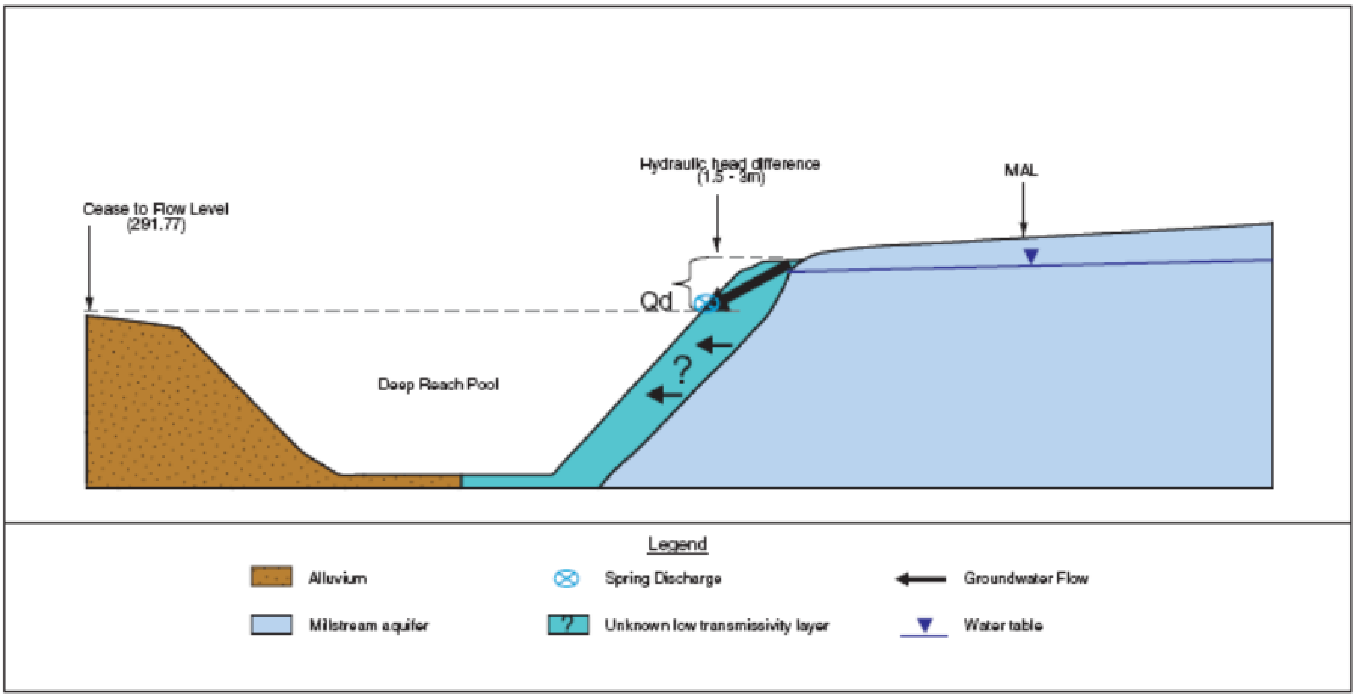


Figure 12: Conceptual diagram showing factors affecting springflow discharge into Deep Reach pool (DoW, 2010)

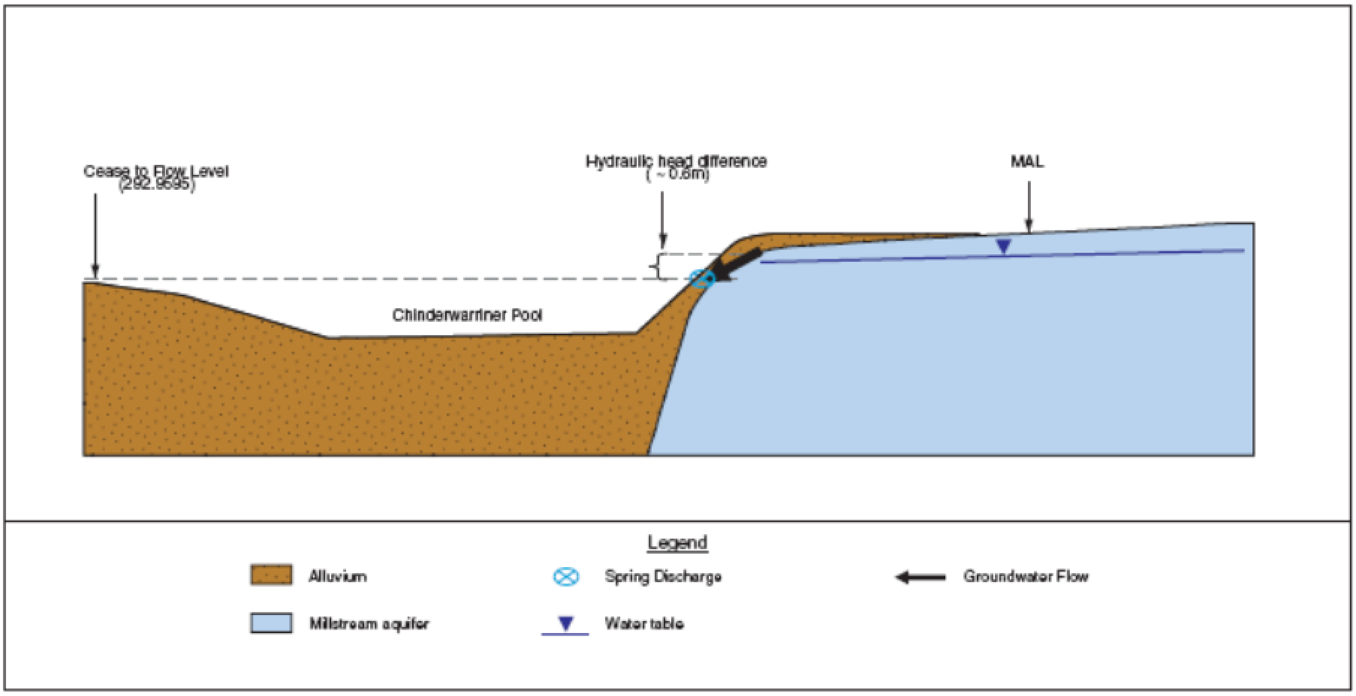


Figure 13: Conceptual diagram showing factors affecting springflow discharge into Chinderwarriner pool (DoW, 2010)

Monitoring at Deep Reach pool indicates the primary source of water is from the Fortescue River. Figure 14 shows pools levels in the Deep Reach pool and the MAL and Figure 16 shows pool levels and the springflow from Deep Reach pool, both showing that pool water is not correlated with the watertable levels or springflow and the pool water level fluctuation is around 1.0m. Figure 18 shows that peaks in pool levels in the Deep Reach pool are directly correlated with the peaks in Fortescue River flows. These graphs support that the primary source of water for Deep Reach pool is the Fortescue River, any impacts to Deep Reach pool are likely due to climatic conditions that affect water supply to the Fortescue River, such as the frequency of tropical cyclones and lows.

Monitoring at Chinderwarriner pool indicates pool water levels remain generally constant and are fed by both springflow and rainfall-runoff. Figure 15 shows pool levels in Chinderwarriner pool and the MAL, Figure 17 shows pool levels and the springflow from Chinderwarriner pool, Figure 19 shows pool levels in the Chinderwarriner pool with Fortescue River flows. The pool water level fluctuation is around 0.2m. These graphs show:

- poor correlation with the resting watertable indicating pool water supply is maintained despite changes to the watertable;
- correlation of pool water levels with springflow from 1995-2007, which occurs during the know wetter period of 1997 to 2013; and
- peaks in the Fortescue River flows coincide with higher pool levels, this correlation is not as strong as for Deep Reach pool because the Chinderwarriner pool is a tributary to the Fortescue, supplied by springflow and surface runoff from across Millstream.

Historically the level in Chinderwarriner pool, which is up to 8m deep, varies in level by 0.2m. This small variation and poor correlation between pool water levels, aquifer monitoring bore 1E and the MAL suggests that Chinderwarriner pool is strongly and directly influenced by the local hydroclimate and (not significantly) indirectly influenced by abstraction from the aquifer.

Crossing pool is directly fed by water from the Deep Reach pool whilst Palm and Livistona pools are fed by flows from Crossing pool and Chinderwarriner pool, via the Delta. Any water level decline in these pools cannot be solely attributed to the proposal. Other factors influencing these pools include evaporation and evapotranspiration loss across the river system and flows down the Fortescue River.

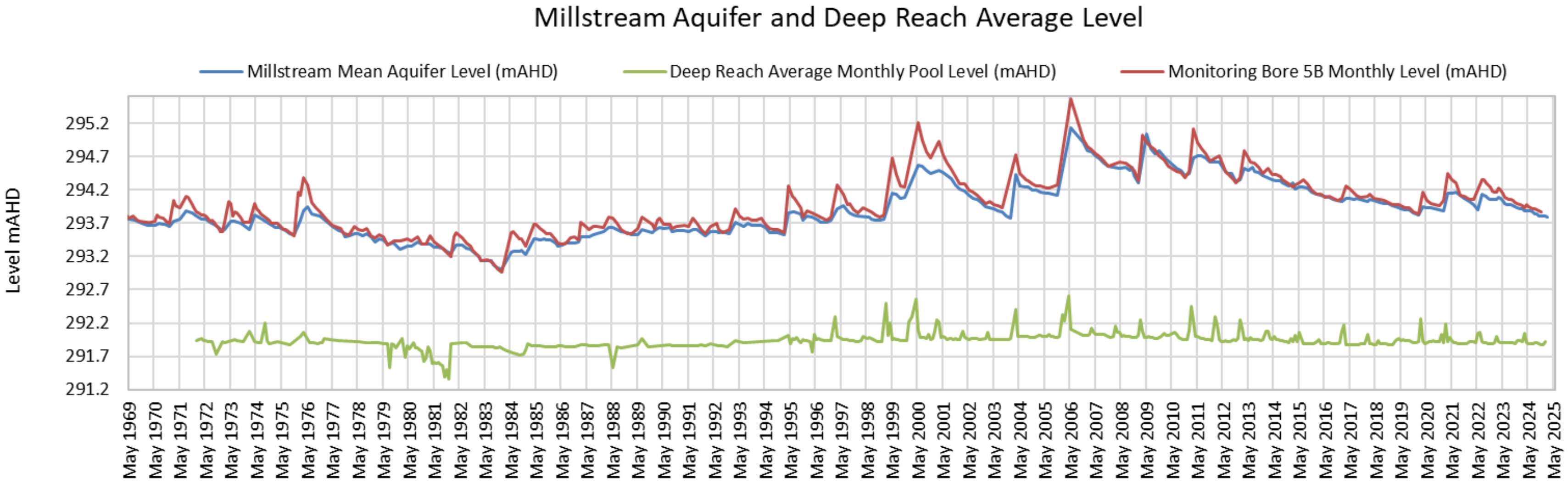


Figure 14: Millstream MAL, Bore 5 B levels and the Deep Reach pool levels

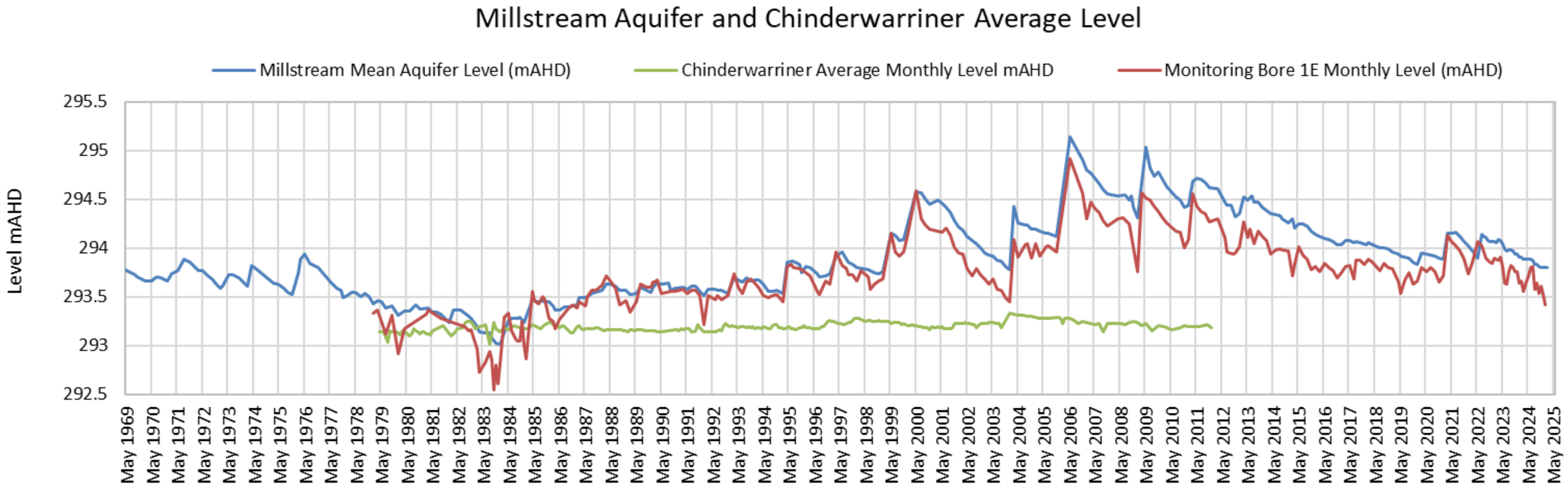


Figure 15: Millstream MAL, Chinderwarriner pool and Monitoring Bore 1E levels

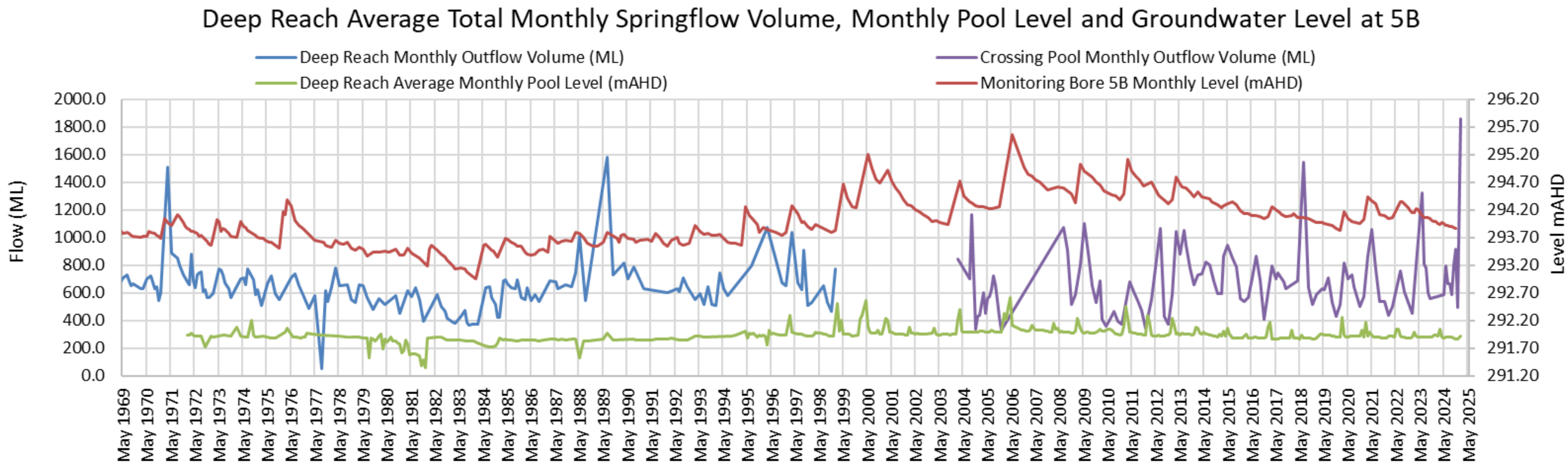


Figure 16: Deep Reach springflow and pool levels.

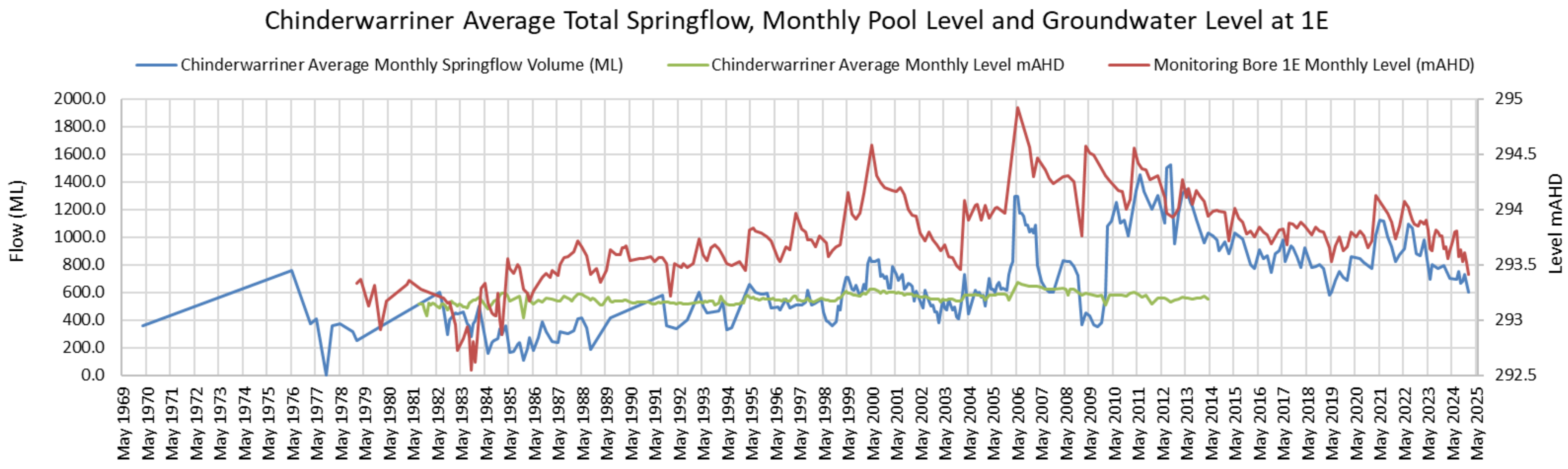


Figure 17: Chinderwarriner springflow and pool levels.

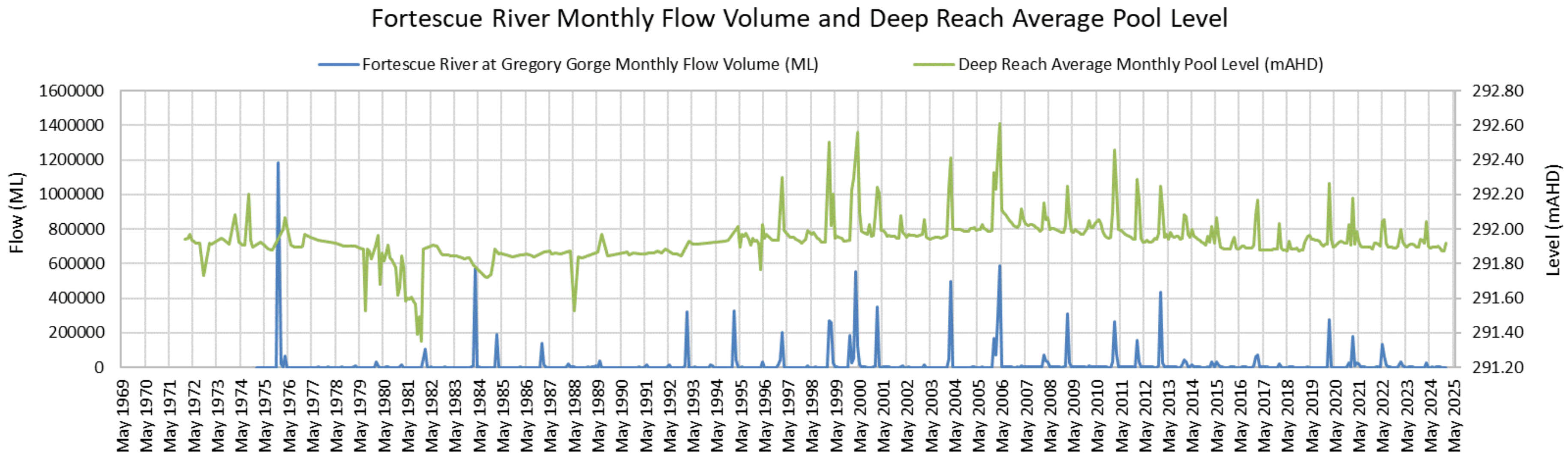


Figure 18: Fortescue River flow volumes and Deep Reach pool levels

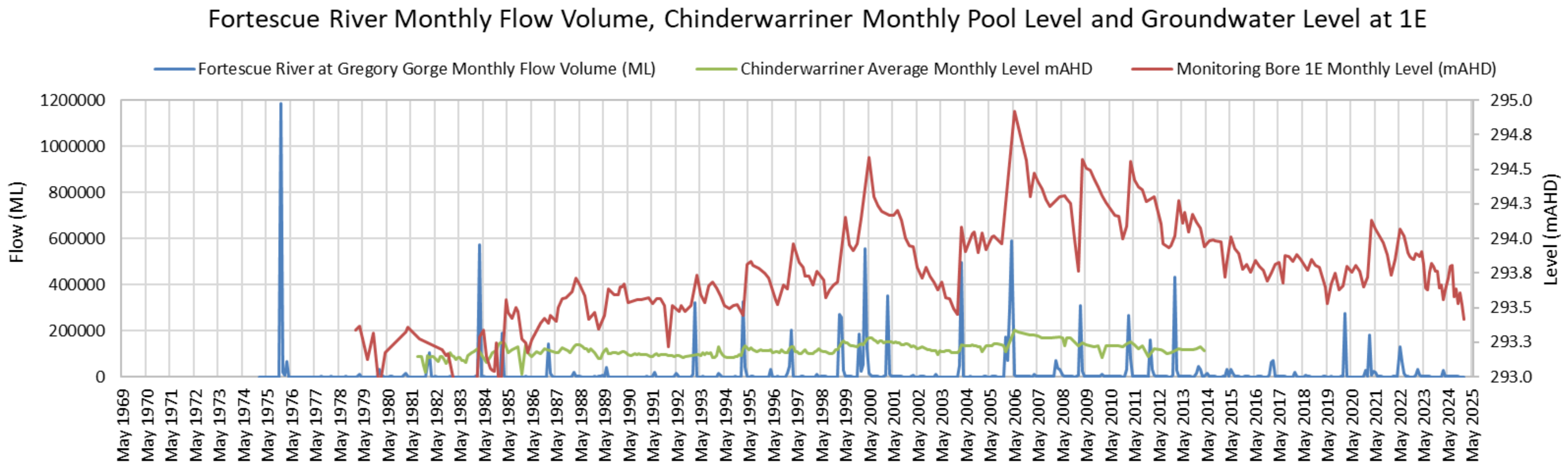


Figure 19: Fortescue River flow volumes, Chinderwarriner pool levels and level at Monitoring Bore 1E

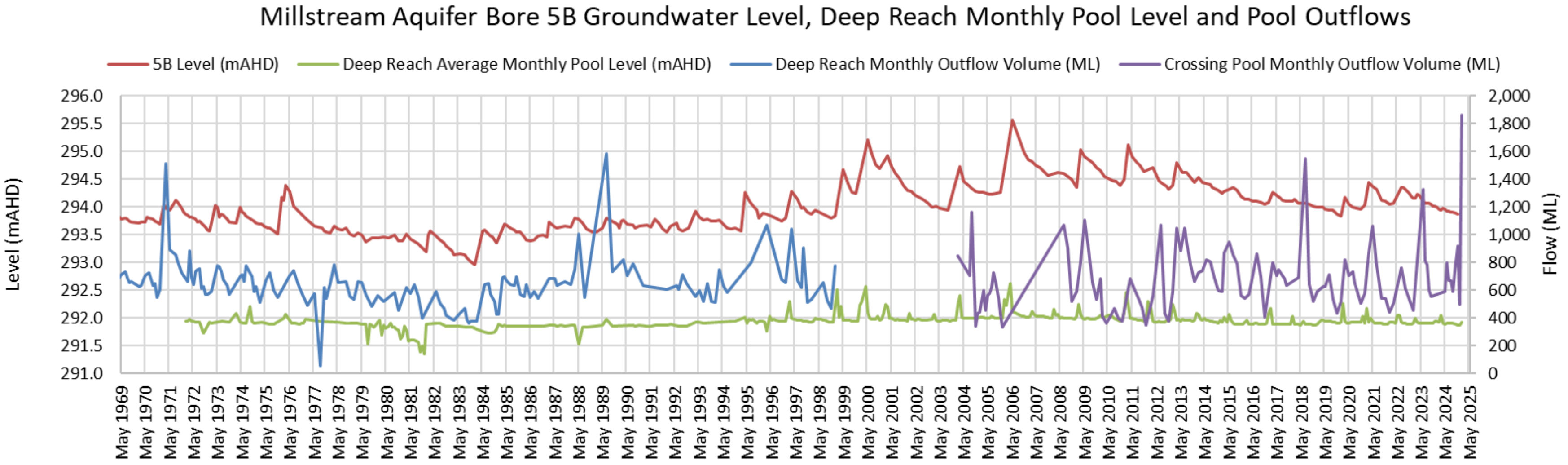


Figure 20: Millstream Aquifer Levels at Monitoring Bore 5B (Closest Aquifer Monitoring bore to Deep Reach Pool) and Deep Reach Monthly Pool Level and Springflow

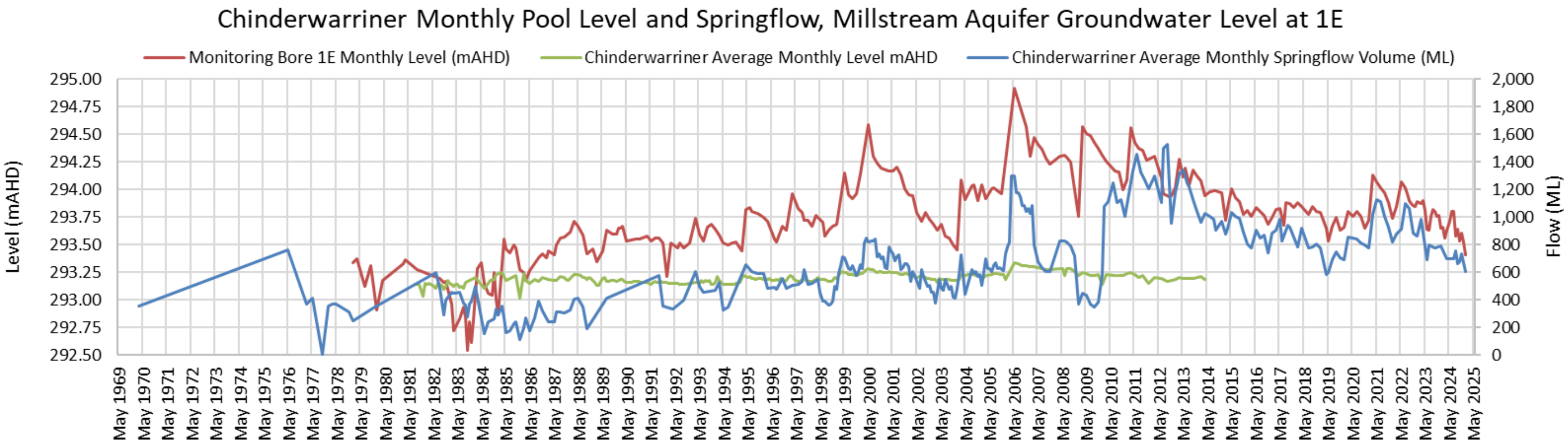


Figure 21: Millstream Aquifer Levels at Monitoring Bore 1E (Closest Aquifer Monitoring bore to Chinderwarriner Pool) and Chinderwarriner Monthly Pool Level and Springflow

Previous monitoring data has been used to determine the potential environmental impacts of groundwater abstraction at the proposed temporary contingency abstraction volume to up to 9GL/a. Figure 22 and Figure 23 show the correlation between groundwater abstraction volumes and the pool levels at Deep Reach and Chinderwarriner pools. There have been three periods where groundwater abstraction has been at or above 9GL/a; 1978-1985, 2001-2004 and 2012-2013.

- During 1978-1985, groundwater abstraction was up to 11GL/a plus an additional abstraction for supplementation, totalling 16GL/a. During this period, below average flows through the Fortescue were observed between 1976 and 1983, including a three-year hydrological drought between 1976-1978. The Deep Reach pool levels started to show decline after three years, declining from 291.90 mAHD to 291.35 mAHD (0.55 m decline), and recovered following supplementation. No long-term impacts to pool water levels from abstraction were observed, as pool water levels recovered.
- During 2001-2004, groundwater abstraction was up to 9.6GL/a with no supplementation. Between 2002 and 2003 below average flows were also observed in the Fortescue River. The pool levels were generally constant during this time at Deep Reach pool with no significant reduction in pool water levels. Pool levels showed a decline after the first year at Chinderwarriner pool. Pool water levels recovered in 2004 following almost 545GL of flow through the Fortescue River during the 2003-2004 wet season.
- During 2012-2013, groundwater abstraction was up to 9.2GL/a with no supplementation. The pool levels were generally constant during this time with no significant reduction in pool water levels.

During the early to mid-1980s the MAL fell dramatically in response to eight years of below average riverflow through the Fortescue River (between 1976 and 1983), a three-year hydrological drought between 1976-1978 and subsequent high abstraction. Commencing in 1979, abstraction was in excess of 9.5GL/a for a seven-year period, peaking at just below 16GL in 1983. Abstraction rates falling below 6GL/a in 1986 following the commissioning of the Harding Dam.

Consequently, the MAL and levels in Chinderwarriner and Deep Reach pools dropped to their lowest recorded level in 1981. At Chinderwarriner pool, flow from the pool ceased in one major outflow channel and decreased significantly in the remaining channels.

As a consequence, areas within the western side of the Millstream Delta, downstream of Chinderwarriner pool, which were normally damp, dried out. This resulted in a decline in the condition of the vegetation in the delta and in the vicinity of Palm pool (Welker, 1995 and 1998).

Supplementation of the Chinderwarriner and Deep reach systems commenced in 1980 and ran until 1986. In 1985 and 1986 rates of supplementation dropping significantly and likely resulted in the observed short term drop in observed springflow and pool water levels.

Previous monitoring data and abstraction volumes (2001-2003 and 2012) has shown short term abstraction of up to 9GL/a does not result in significant long-term impacts to the pool water levels of the Millstream Wetland. The proposed temporary contingency abstraction volume to up to 9GL/a is therefore not expected to result in long-term significant impacts to pool water levels.

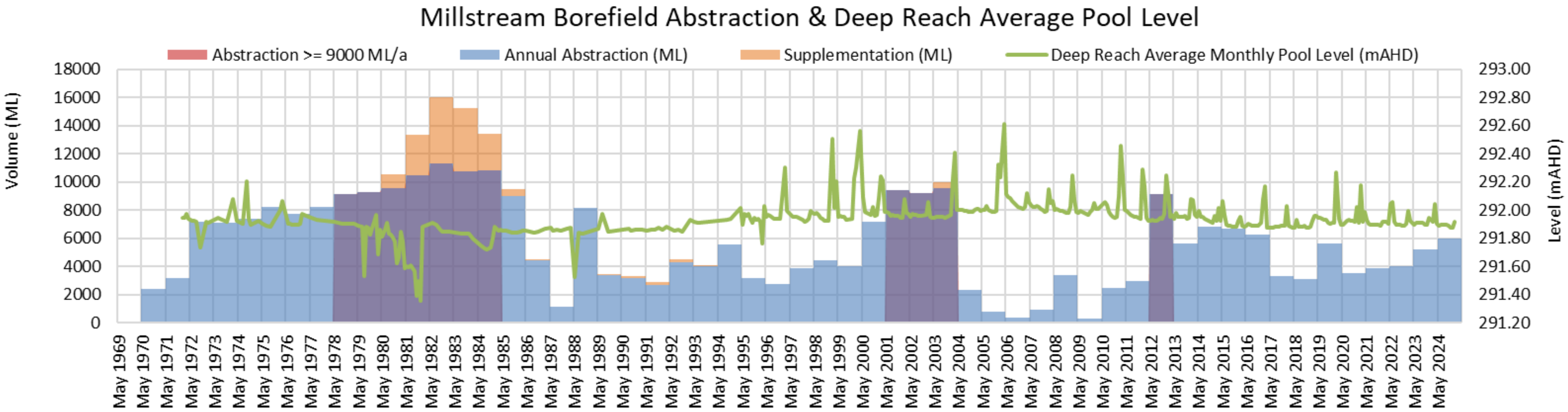


Figure 22: Groundwater abstraction volumes and Deep Reach pool levels

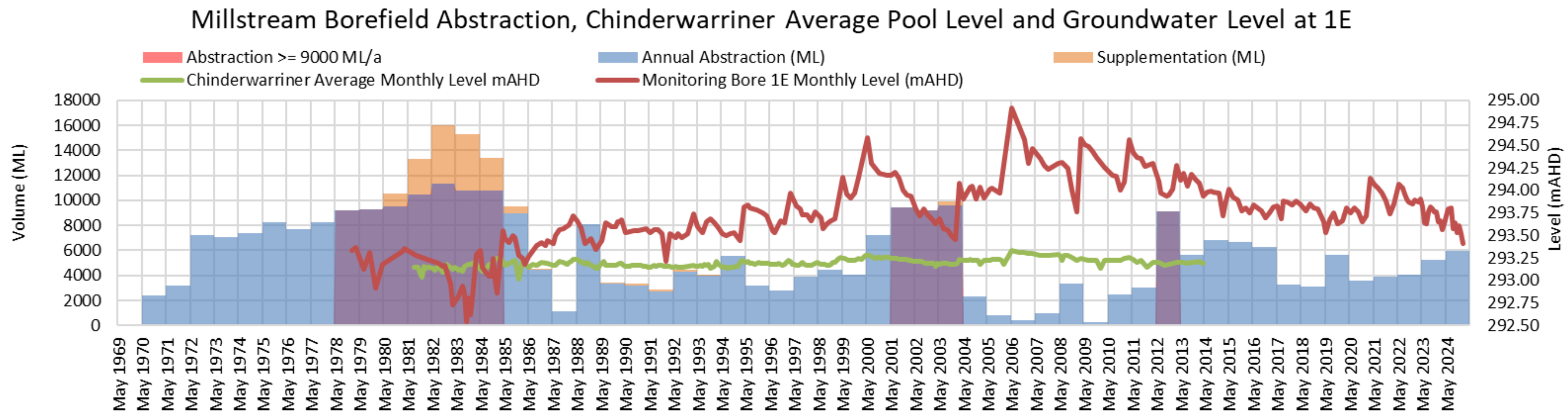


Figure 23: Groundwater abstraction volumes, Chinderwarriner pool level and groundwater level at Bore 1E

Potential indirect impacts of to the Millstream Wetlands and permanent pools can be assessed using historical monitoring results as an indication of future abstraction impacts. Monitoring and setting of trigger values have changed with ongoing monitoring, and improved understanding of the complex environment.

The Millstream springflow trigger values were initially presented 1998 Millstream Water Management Plan (Welker Environmental Consultancy, May 1998) and summarised in the Braimbridge (2010) report. The triggers outline the rate of groundwater discharge that is required to maintain the health of these pools. These rates were:

- Chinderwarriner pool: Instantaneous flow rate of 0.15 kL/s (12.96 ML/day) and ≥ 0.2 kL/s during November and December.
- Deep Reach pool: Minimum annual average discharge of 6.5GL/a (0.20 kL/s) to the riverine system below Deep Reach. For November and December > 0.27 kL/s.
- Crossing pool: Instantaneous flow rate of 0.08 kL/s and ≥ 0.11 kL/s during November and December.
- Minimum mean aquifer level (MAL): MAL not to fall below what is considered to be the historical minimum of 293.10 m AHD.

These rates were developed to maintain the water requirements of groundwater dependent values following the Millstream Environmental Water Requirements Study (Welker Environmental Consultancy, December 1995). The criteria specify minimum discharge rates from groundwater fed pools, acceptable rates of decline of aquifer level and a minimum MAL. The outflow based on the measured, documented, relationship between aquifer level and spring discharge and estimates of the environmental water demand of ecosystems downstream of the springs.

The springs discharge directly into pools and the criteria are applied as rates of outflow from the pools.

Braimbridge (2010) outlines what impacts are expected where the discharge from the groundwater to Chinderwarriner, Deep Reach and Crossing pools are less than the criteria, outlined above; and the impacts expected to the Millstream Wetland systems where the MAL is less than 293.10 mAHD.

Exceeding these trigger values does not result in significant impacts to the pools, but the frequency of exceeding these trigger values is considered to assess the actual observable impacts. The report concludes that a trigger exceedance rate of 17% was acceptable, based on evidence that this frequency of criteria breach in the past has not had a lasting detrimental effect on the dependent ecosystems. The sustainable yield reported was groundwater abstraction at 6GL/a.

Extrapolating from the graphs in Braimbridge (2010), a 9GL/a abstraction volume is expected to exceed:

- The Chinderwarriner pool trigger around 67% of the time.
- The Deep Reach pool trigger around 40% of the time.
- The MAL around 8% of the time.

The trigger values were updated in 2014 and again in 2020 (Table 9) as outlined in the WRMOS. The revised criteria allowed for staged responses, with targets, triggers followed by criteria, adjusted to changes in climatic conditions, knowing that the pools levels are predominantly surface water fed and reliant on cyclonic events. The target, trigger and criteria to be use for any year, is based on the recharge class (Table 10) which is based on monitoring recharge at Gregory Gorge (Fortescue River). The use of the applicable recharge class, which determines which responses criteria is used for any year, is pre-agreed with DWER each year.

Table 9: Response Values for Millstream pools

Recharge class	Recharge Deep Reach flow triggers and criteria measured below Crossing pool (Location 3*) with corresponding groundwater levels as measured in Bore 58					
	Target		Trigger		Criteria	
	Flow kL/s	Bore 5B mAHD	Flow kL/s	Bore 5B mAHD	Flow kL/s	Bore 5B mAHD
3	0.26	294.14	0.23	293.98	0.21	293.78
2			0.23	293.98	0.21	293.78
1			0.21	293.78	0.18	293.6
	Chinderwarriner flow triggers and criteria with corresponding groundwater levels as measured in Bore 1 E					
	Target		Trigger		Criteria	
	Flow kL/s	Bore 1E mAHD	Flow kL/s	Bore 1E mAHD	Flow kL/s	Bore 1E mAHD
3	0.27	293.84	0.23	293.58	0.20	293.49
2			0.23	293.58	0.20	293.49
1			0.2	293.49	0.16	293.41
*Location 3 coordinates - GDA94: Zone:50 E:508915.3 N:7614020.4						

Table 10: Recharge Class - water availability based on wet season flow

Recharge Class	Water Availability condition	Total Wet Season flows (DEC-April) ML
1	Drought	< 43,000 for previous 3 or more years
2	Dry	<43,000 for previous 1 or 2 years
3	Average to wet	> 43,000 (if MAL is < 294.00 mAHD at the beginning of the water year, recharge class 2 should be applied).

Additional discharge from the Millstream aquifer occurs through the Woodley, Peters and Palm Creeks. These three creeks, when flowing, maintain additional supply of water to Palm pool (via Woodley), Livistona pool (via Peters) and downstream of Livistona (via Palm).

Monitoring at Woodley, Peters, and Palm Creeks indicates the volume of springflow feeding the creeks is historically very low, and regularly supplemented by rainfall-runoff following significant and smaller acute localised climate events.

This is illustrated by three distinct peaks in springflow (L/sec) in 1999, 2006 and 2009 (Plate 1 to Plate 3), which coincide with tropical cyclones (TC) in 1999 and 2006 and a significant tropical low in 2009:

- 1999: TC Tiffany (January), TC John (December).
- 2006: TC ClareC3 (January) followed by TC Emma C1 (February), TC Glenda C2 (March) (largest recorded recharge event).
- 2009: Tropical low floods large portion of Pilbara (second largest recharge, and localised 1/50 - 1/100-year rainfall event).

Monitoring at Woodley, Peters, and Palm Creeks (Plate 1 to Plate 3) demonstrates the low background springflow volumes to these pools and low correlation with changes to groundwater abstraction volumes.

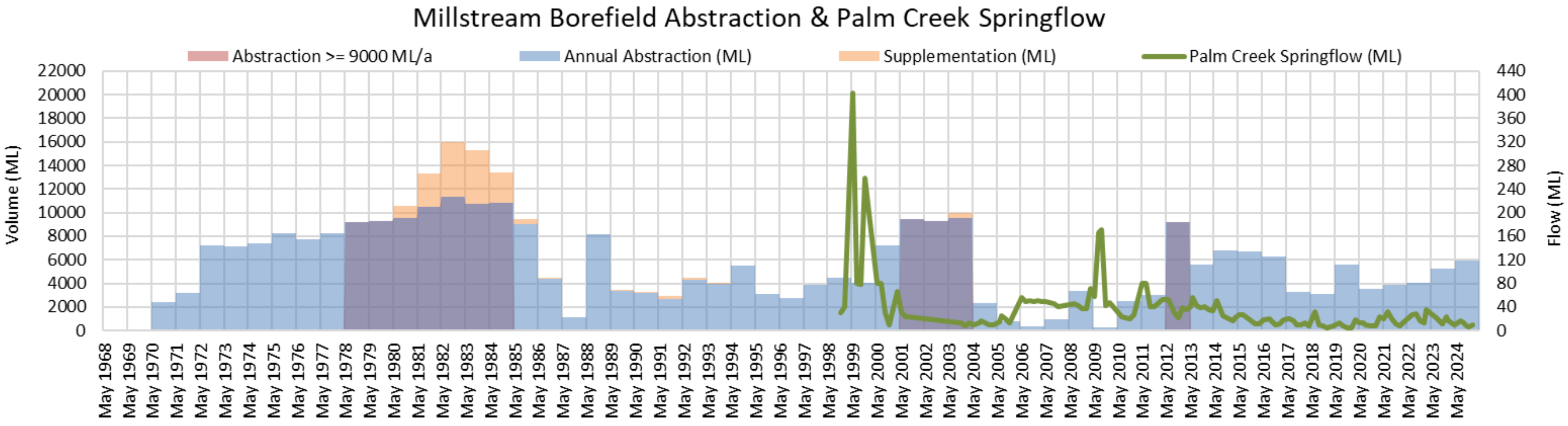


Plate 1: Springflow at Palm Creek

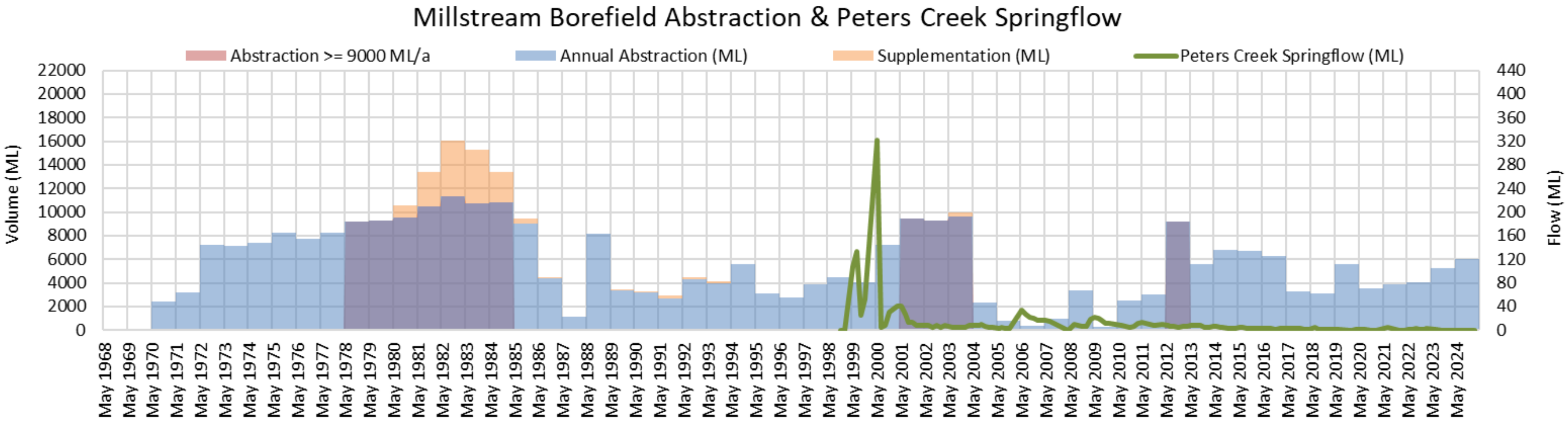


Plate 2: Springflow at Peters Creek

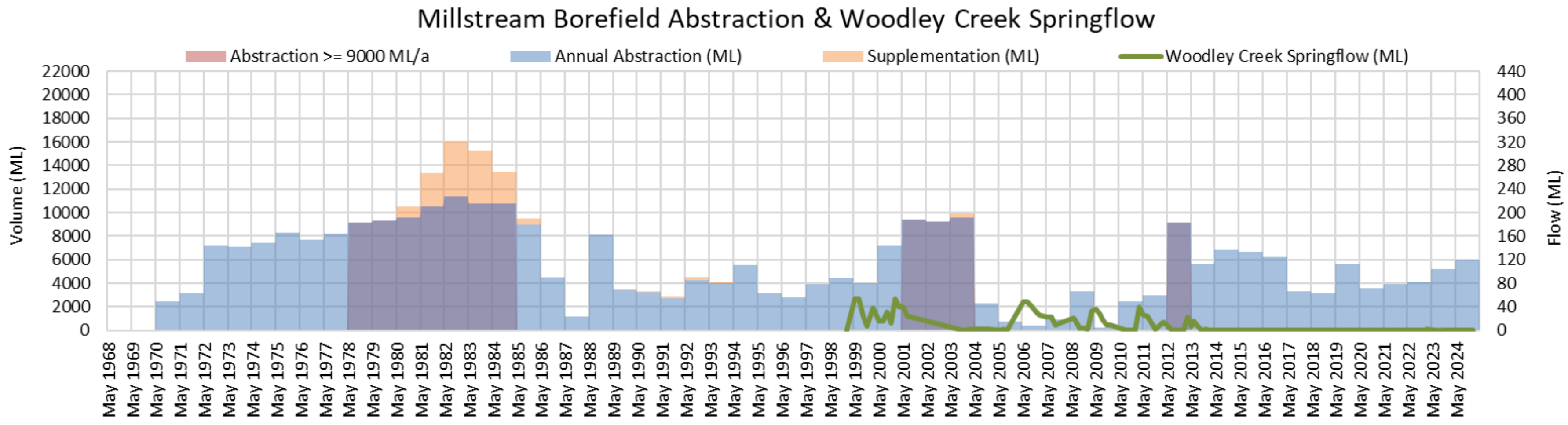


Plate 3: Springflow at Woodley Creek

Prior to 1985 Millstream aquifer was the primary source of water for Karratha, Dampier and Wickham.

During the early to mid-1980's the MAL fell dramatically in response to abstraction at levels above 9.5GL/a for a 7-year period (peaking at just below 16GL in 1983). As a consequence, areas within the downstream western side of the Millstream Delta, which were normally damp, dried out resulting in a decline in the condition of the vegetation (Welker, 1995 and 1998). Flow also ceased in one major channel and decreased significantly in the remaining channels resulting in a fall in local alluvial groundwater levels (Welker, 1995).

Management responses during this period required the triggering of supplementation when flow ceased in channels 3 and 4 into the Fortescue River.

In 1980 supplementation commenced. Between 1980 and 1986 between 0.2 to 4.9GL/a of water was abstracted from the Millstream aquifer and released immediately upstream of Chinderwarriner pool.

In 1985 the Harding Dam was commissioned. The two sources forming a conjunctive water supply to the town and reducing abstraction from Millstream to below between 2 to 9GL/a.

Since the current WRMOS was approved in 2014:

- Triggers and criteria values have not been breached for the MAL8 (the MAL calculated from 8 monitoring bores dispersed across the aquifer).
- Trigger values have been reached twice at Deep Reach pool:
  - In December 2020 following failed wet seasons in 2017-18, 2018-19 (wet season riverflow <43GL) and a poor recharge response in 2019-20, when no rainfall and subsequent runoff occurred downstream of the aquifer and pools.
  - In response, management responses as outlined in Table 15 of the WRMOS were implemented. These responses included increases to monitoring frequency, budgeting for vegetation monitoring (GHD, 2022), increases to the frequency of reporting to DWER and TWG, commencement of downstream flow observations at Livistona and spreading of abstraction across the borefield. Supplementation planning was also triggered.
    Monitoring indicates that groundwater levels, springflow volumes and TDS levels did not reach the criteria but did recover to levels above the triggers in early 2021 following the combined influence of Tropical Cyclone Damien and a significant tropical low. Observations of flow downstream of Livistona indicated no detrimental impacts to the level of outflow from the pool.

    Vegetation condition monitoring, undertaken by GHD in November 2021, indicated that overall tree condition had increased since the previous monitoring in 2019 (GHD, 2022). A large change in condition score rating average was also observed between the 2017 and 2021 assessments, attributed to the fires and/or floods that occurred soon after the 2017 survey.

  - In late 2023 the triggers were reached and trending towards the criteria following a failed wet season in 2021-22, poor recharge in 2022-23 and a failed wet season in 2023-24.

    Management responses include increasing the monitoring frequency through the installation of telemetered groundwater level devices in the aquifer and in the vicinity of the pool, vegetation monitoring (scheduled for April 2025 and November 2025), increased reporting of results to DWER and TWG, spreading of take across the borefield and reduction of use (through demand management and leak detection and repair works).

    Attempts were also made to obtain flow observations at Livistona pool (via drone) but were mostly unsuccessful. Further work to find a safe and sustainable solution are ongoing.

Continuous monitoring of levels in the aquifer and in the vicinity of Deep Reach pool are providing valuable insight into the current behaviours of the system.

- The springflow trigger was reached, in January 2025, at Chinderwarriner pool following a failed wet season in 2021-22, poor recharge in 2022-23 and a failed wet season in 2023-24.

  Management responses include increasing the monitoring frequency through the installation of telemetered level devices on the aquifer and in the downstream delta, vegetation monitoring (scheduled for late April 2025 and November 2025), increased reporting of results to DWER and TWG, spreading of take across the borefield and reduction of use (through demand management and leak detection and repair works).

  Continuous monitoring of levels in the Millstream aquifer and in the vicinity of Deep Reach pool are providing valuable insight into the current behaviours of the system.

5.7 Mitigation

The minimisation and management measures to minimise and mitigate impacts are presented in the WRMOS (Appendix B), which has been prepared using the:

- Antao, M. 2013, Pilbara monitoring program to support the Pilbara groundwater allocation plan, Department of Water, Government of Western Australia.
- Department of Water 2013, Pilbara Groundwater Allocation Plan 2013, Water resource allocation and planning report series Report no 55.
- Haig, T 2009, The Pilbara coast water study, Department of Water, Hydrogeological record series, Report HG34, 183 p.

The WRMOS outlines the responses when criteria are breached for the Millstream aquifer, these are outlined below.

- Level 1 monitoring and reporting
  - Increase frequency of groundwater and flow monitoring to fortnightly as soon as practicable.
  - Increase reporting to DWER and TWG on monitoring results and implementation of Level 1 and 2 responses to monthly.
  - Undertake remote sensing monitoring and budget for end of dry season in-situ vegetation monitoring.
  - Increase downstream flow monitoring.
- Level 2. Supplementation Plan
  - Trigger supplementation plan.
- Level 3. Scheme response
  - Commence negotiations with RTIO to take additional water from Bungaroo and consider other contingencies.
- Level 4. Critical response
  - Supplementation to proceed with consideration of targets set in Table 12 and in discussion with TWG.
  - Use contingency sources.

- Reduce take

When triggers have been reached, the appropriate responses have been implemented in accordance with the WRMOS and as agreed by the TWG. Implementation of the management measures have mitigated significant long-term impacts to the environment.

In accordance with the WRMOS, summaries of compliance against the licence conditions are prepared annually and every fifth year requires a Water Monitoring Review (examining longer term impacts and compliance) to be provided to DWER.

5.8 Assessment and Significance

Observations indicate that pool level trends within the Millstream Wetlands are primarily due to the influence of antecedent hydroclimatic conditions and not directly related to groundwater abstraction.

The proposal has the potential to indirectly contribute to impacts to the Millstream Wetlands by reducing the volume of the springflow entering Millstream pools at prolonged high abstraction volumes. Any observable changes to Millstream pools at sustainable abstraction volumes, are primarily due to reduction in runoff from the upstream Fortescue River catchment. This reduction in runoff is the consequence of a recent decline in the number and intensity of tropical cyclones and lows which are outside the influence of the proposal. The reaching of trigger values in Deep Reach and Chinderwarriner pools, were due to failed wet seasons, with the exception of the 1980's which was due to periods of extended over abstraction in excess of 10GL.

Baseflow into the Woodley, Peters and Palm Creek is supplied in the form of springflow from the aquifer during high water level periods and is supplemented by rainfall-runoff from Millstream during significant climatic events. Any reduction in springflow attributed by the proposal is not likely to impact the water levels in the pools, baseflow volumes through the creeks are naturally low and supplemented by runoff from the Millstream system during significant climatic events.

Previous monitoring showing prolonged (7 consecutive years) groundwater abstraction in excess of 9.5GL/a, and peaking at just below 16GL/a, illustrates the potential impacts to the Millstream Wetland system. In 1981 pool levels in both Deep Reach and Chinderwarriner dropping significantly and resulting in a decline in flow exiting Chinderwarriner pool. However, both springflow and pool level data also indicate how the levels in the systems recovered, within a year, when following recharge to the aquifer and a decrease in abstraction volumes back to sustainable volumes. This demonstrates that abstraction well in excess of the proposed 9GL/a did not result in significant long-term impacts to the pool water levels.

This proposal for temporary abstraction of no greater than 9GL/a is therefore not expected to result in long-term significant impacts to pool water levels.

5.9 Environmental Outcomes

The sustainable yield and allocation planning studies and real-life monitoring data for the proposal has predicted and shown that:

- Abstraction up to 9GL/a does not adversely affect pool water levels; antecedent hydroclimatic conditions are the primary driver.
- Pool water levels have recovered following periods of groundwater abstraction greater than 9GL/a.

Consequently, the proposal is not expected to result in long-term, permanent observable change, any observable changes are likely to be attributable to climatic events and the proposal is not likely to result in significant impacts to inland waters. The EPA objective "*To maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected*" can be met.

6. Social Surroundings

6.1 EPA Environmental Factor and Objective

The objective of the EPA (2023) Environmental Factor Guideline for Social Surroundings is:

To protect social surroundings from significant harm.

6.2 Relevant Legislation, Policy and Guidance

- Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023).
- Environmental Factor Guideline - Social Surroundings (EPA, 2023).
- EPA (2023) Technical Guidance Environmental impact assessment of Social Surroundings – Aboriginal cultural heritage.
- *Aboriginal Heritage Act 1972* (AH Act).
- *Rights in Water and Irrigation Act 1914* (RiWI Act).

The assessment of social surroundings as a key environmental factor under the EP Act is the extent to which cultural heritage values are directly affect or are affected by physical or biological surroundings and where (must) be a clear direct link between a proposal's impact on the physical or biological surroundings and the subsequent impact on a person's aesthetic, cultural, economic or other social surroundings (EPA, 2023). For social surroundings to be assessed as a key environmental factor, the effect on social surroundings must be significant, whereby a direct effect on the physical or biological environment, must be significant.

Table 11: Assessment of the Proposal against the EPA (2023) Technical Guidance - Environmental impact assessment of Social Surroundings – Aboriginal cultural heritage

3.1 Aboriginal Cultural Heritage (ACH) impacts where harm is avoided or minimised by the AH Act 1972 *Are AH Act 1972 processes likely to mitigate the potential impacts to ACH values and meet the EPA's objective for the social surroundings environmental factor?*
Within EPA's (2023) Technical Guidance on Social Surroundings, in relation to the EP Act, it's stated "*for social surroundings to be considered in EIA, there must be a clear link between a proposal['s]…impact on the physical or biological surroundings and the subsequent impact on a person's aesthetic, cultural, economic or social surroundings*". The focus of the AH Act is on the potential for damage to be caused to heritage and how that damage can be avoided, mitigated or managed. The proposal's activities are limited to groundwater abstraction and do not include ground disturbance or clearing, as such no direct impacts to the Millstream Wetlands, Millstream Homestead, burial grounds, archaeological sites or other cultural places are expected as a result of implementation. Consideration is therefore given to whether the aboriginal cultural heritage (ACH) values of the Millstream Wetlands may be indirectly impacted by groundwater abstraction altering the volume of the springflow from the aquifer entering Millstream Wetlands pools and rivers. However, as per Section 5.6.2, monitoring data demonstrates the potential impacts on pool and river levels are primarily due to

hydroclimatic conditions and not directly related to groundwater abstraction as a result of implementation of the proposal.

Where there is no direct impact it's not necessary to rely on the AH Act to ensure that potential impacts can be appropriately considered and, if necessary, mitigated, because the RiWI Act licensing decision-making process provides a comprehensive framework for considering potential impacts, including those related to ACH. The references within the RiWI Act, and associated policy documents, for the need to consider sustainable use of water resources, protection of their ecosystems and environment, and public interest considerations in decision-making ensures that environmental and social (heritage) impacts of the proposal will be considered.

3.2 ACH impacts not considered by AH Act 1972

i. *Outside the area likely to be subject to the AH Act 1972 processes, are there places where the proposal is likely to have a physical or biological impact which is likely to cause significant harm to ACH values?*

ii. *Inside the area likely to be subject to the AH Act 1972 processes, are there physical or biological impacts which may cause significant harm to ACH values which the AH Act 1972 will not apply to?*

The proposal's activities are limited to groundwater abstraction and do not include ground disturbance or clearing, as such no direct impacts to ACH are expected. Regarding the potential for groundwater abstraction to indirectly impact cultural values of Millstream Wetlands by altering pool and river levels; monitoring data demonstrates potential impacts on pool and river levels, and duration of impacts are primarily due to hydroclimatic conditions.

Measures to minimise and mitigate impacts to springflow into the Millstream Wetlands and pools are presented in the WRMOS, and the Corporation is committed to ongoing consultation with YAC on management of the Millstream source. As such, it's not considered likely that ACH values are significantly harmed as result of groundwater abstraction from implementation of the proposal, and no residual impacts are expected.

3.3 Reasonable steps to consult

Were reasonable steps taken to consult with relevant people about physical or biological impacts likely to cause significant harm to ACH values?

Millstream is a significant cultural landscape to the Yindjibarndi people. YAC is the Prescribed Body Corporate with responsibility for the management of Yindjibarndi country on behalf of Yindjibarndi people. Both the MHCC and TWG include representatives from YAC, who are involved in the joint management of the WPWSS sources to ensure that water dependant values are protected.

MHCC meets annually and was established to provide strategic advice to the DWER on management issues associated with WPWSS sources, while the TWG meets quarterly on the day-to-day operation, monitoring and management of Harding Dam and Millstream Borefield. The MHCC and TWG provide an opportunity to discuss monitoring and abstraction, collaborate on mitigation and maintenance activities and for the stakeholders to have input on the management of the WPWSS sources.

The WRMOS sets out the adaptative management process for Millstream in accordance with the Pilbara Groundwater Allocation Plan. The adaptative environmental assessment and management, through improved knowledge obtained from monitoring data that refines interim EWPs, is to incorporate improvements into the management guidelines as early as practicable. DWER manages revisions of EWPs (on behalf EPA) through consultation with the MHCC and TWG, of which YAC is a member. This process provides YAC the opportunity to jointly manage the Millstream source and thereby protect ACH values.

Outside the MHCC and TWG, the Corporation engages with YAC on project related matters in the Millstream area, and the Corporation CEO has met with YAC's CEO on several occasions to discuss the WPWSS. Monthly meetings between the Corporation, YAC and DWER were also established in December 2024, due to heightened interest in Millstream, to regularly discuss issues and progress on actions.

The established consultation processes ensure the provision of sufficient information to key stakeholders on monitoring and abstraction, and for collaboration on the management of WPWSS sources to avoid harm to ACH values.

6.2.1 Aboriginal Heritage Act 1972 (AH Act).

The Corporation does not consider the AH Act to solely regulate potential impacts to cultural values. The RiWI Act is given the scope to consider such a broad range of issues under the RiWI Act decision making process. However, to the extent that there could be Aboriginal heritage concerns that are not directly related to the abstraction of the water, the protections in the AH Act apply.

The AH Act is part of the broader compliance landscape that protects Aboriginal cultural heritage. The AH Act prohibits a person from destroying, damaging, concealing or altering an Aboriginal site or object without consent.

The Corporation has not applied for section 18 consent because of ongoing consultation with Traditional Owners undertaken as part of the RiWI management framework removes the risk of potential impacts to cultural values.

6.2.2 Rights in Water and Irrigation Act 1914 (RiWI Act).

When deciding whether or not to assess a proposal, the EPA can take into account other statutory decision-making processes "that can mitigate the potential impacts of the proposal on the environment" (section 38G(4) of the EP Act). The Corporation considers that the RiWI Act can mitigate the potential impacts of the proposal on the environment. The decision-making process for the grant of a section 5C licence renewal under the RiWI Act provides a comprehensive framework for considering all of the potential impacts that are raised in the YAC referral and relevant to an EPA Part IV assessment, including both environmental and ACH impacts. When considering an application for renewal of a section 5C licence, the Minister has a broad discretion to consider anything that is relevant under clauses 7 and 22 of Schedule 2 of the RiWI Act. There are no relevant restrictions, geographically, in terms of impacts or generally. The assessment of impacts from the proposal can therefore be included under clauses 7 and 22 of Schedule 2 of the RiWI Act, via issuing of a 5C licence.

Whilst the EPA's factor objectives are not expressly referred to in the RiWI Act or guidance, all of the key environmental factors and objectives (for flora and vegetation, subterranean fauna, landforms, terrestrial fauna, inland waters and social surroundings) can and must be taken into account in the section 5C decision-making process, to the extent that the factors are:

- part of the Millstream aquifer ecosystem and environment.
- potentially impacted by the ecologically unsustainable use of the aquifer.
- a matter of public (including social) interest; and/or

- considered by the Minister to be relevant.

The YAC referral concerns the potential impacts arising from the proposed abstraction, in particular matters like declining ground and surface water levels, seasonal availability of water, erosion, salinity, water temperature changes and water quality, and the implications those direct impacts could have on flora, stygofauna, terrestrial fauna, inland waters, landforms and ACH values in the area. All of these potential impacts can be considered as part of a section 5C licence renewal decision-making process.

As part of the 5C licence decision-making processes, in accordance with Part III, section 4 of the RiWI Act, the Minister must:

a provide for the management of water resources, and in particular:
  (i) sustainable use and development to meet the needs of current and future users; and
  (ii) protection of their ecosystems and the environment in which water resources are situated, including by the regulation of activities detrimental to them;
b promote the orderly, equitable and efficient use of water resources;
c foster consultation with members of local communities in the local administration, and to enable them to participate in that administration; and
d assist the integration of the management of water resources with the management of other natural resources.

The assessment and decision-making process for a 5C licence must consider Part III, section 4 of the RiWI act, and therefore meets the requirements for other statutory decision-making processes "that can mitigate the potential impacts of the proposal on the environment" stated under section 38G(4) of the EP Act.

Licensing decisions relating to the Millstream aquifer will also be guided by the Pilbara Groundwater Allocation Plan (2013). The assessment of cumulative impacts is an inherent part of the RiWI Act licensing framework by virtue of the fact that the Act is, a water allocation regime.

The framework for section 5C licences under the RiWI Act (including the renewal application process and ongoing consultation/engagement, management, monitoring and reporting obligations) allows for the assessment, protection and management of all of the environmental factor objectives including:

- protect flora and vegetation so that biological diversity and ecological integrity are maintained.
- protect subterranean fauna so that biological diversity and ecological integrity are maintained.
- protect terrestrial fauna so that biological diversity and ecological integrity are maintained.
- maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected; and
- to protect social surroundings from significant harm.

6.3 Receiving Environment

A search of the ACH Registered sites is presented in Table 12 and shown in Figure 24.

Table 12: Aboriginal Cultural Heritage (ACH) Registered sites within a 4km radius of the Millstream Borefield

ACH Identifier	Place Name	Place Type
ACH-00000659	MILLSTREAM CAMP BURIALS (MS04)	Burial; Creation / Dreaming Narrative

ACH Identifier	Place Name	Place Type
ACH-00006350	MILLSTREAM SCARRED TREE	Modified Tree
ACH-00011386	PUMP PLAIN BORE.	Other
ACH-00011389	PIPELINE SERIES 2	Artefacts / Scatter
ACH-00011345	SOUTH CROSSING POOL 2.	Artefacts / Scatter; Camp
ACH-00011346	CROSSING POOL SERIES 3.	Camp; Quarry
ACH-00011348	CROSSING POOL SERIES 5.	Other
ACH-00011349	MILLSTREAM	Artefacts / Scatter
ACH-00011857	NEWALL'S SITE.	Artefacts / Scatter; Camp
ACH-00000658	MAYUWUNHA.	Artefacts / Scatter; Historical
ACH-00000668	THARRARRNHA BURIAL	Burial; Artefacts / Scatter
ACH-00000670	WARTUNHA.	Burial; Artefacts / Scatter; Camp; Historical
ACH-00000697	JAWURRINHA.	Ritual / Ceremonial; Historical; Quarry
ACH-00007155	NGANYANGUNGA.	Camp; Ritual / Ceremonial; Creation / Dreaming Narrative; Hunting Place; Water Source
ACH-00007156	MAYARNHA	Ritual / Ceremonial; Creation / Dreaming Narrative
ACH-00007134	MILLSTREAM HSD BURIALS	Burial
ACH-00007856	PALM POOL.	Camp; Creation / Dreaming Narrative; Plant Resource; Water Source
ACH-00006890	SIX MILE WELL	Quarry
ACH-00011394	ISLAND, MILLSTREAM	Artefacts / Scatter
ACH-00011395	CHERT QUARRY AND WORKSHOP.	Other
ACH-00011893	URALA.	Ritual / Ceremonial; Creation / Dreaming Narrative; Plant Resource; Water Source
ACH-00011894	MUNGALA DALU	Ritual / Ceremonial
ACH-00012034	MILLSTREAM BURIAL	Burial
ACH-00012035	GURAN	Ritual / Ceremonial; Creation / Dreaming Narrative; Quarry
ACH-00012036	WILGI DALU, MILLSTREAM	Ritual / Ceremonial; Creation / Dreaming Narrative; Ochre; Quarry

The places of cultural value to the Yindjibarndi people have been taken directly from the YAC referral (YAC, 2024). These places comprise the Millstream river and pools, providing ethnographic places of cultural significance (Table 13).

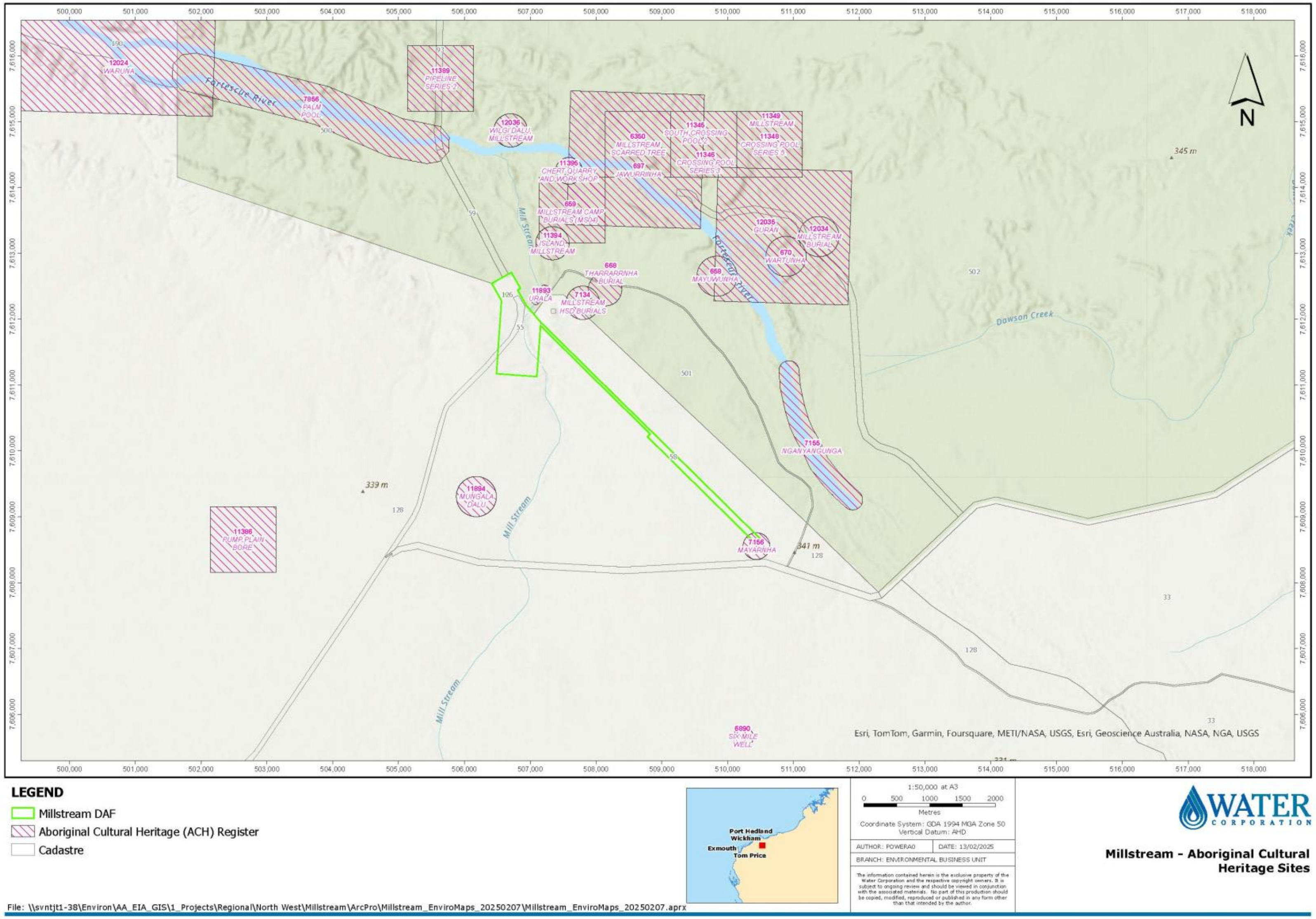


Figure 24: Aboriginal Cultural Heritage (ACH) Registered sites in the vicinity of the Proposal

Table 13: Places of cultural value to the Yindjibarndi people

Location	Aesthetic Values	Historic Values	Social Values	Spiritual Values	Scientific Values
Murlurnmun yjurna Wurndu (Crossing pool)	Highlight values created by the natural landscape, including the flora and fauna of the place, which can be experienced through sight, sound and smell here. The Millstream area is a lush oasis in the broader landscape now, and in the past. The area and places within it evoke strong feelings for the Yindjibarndi people.	A place associated with Jirndawurrunha (Millstream Station), a place associated with significant historic themes and specific Yindjibarndi people.	A place to camp and as a place where important resources were available. It also has social value as a place that Yindjibarndi people can fish and swim, after taking appropriate cultural measures.	A place where significant flora and fauna live and as a place, in the landscape of the Yindjibarndi Nation, where spirits are acknowledged, including those of the animals and trees. It is a place where the Barrimirndi or Warlu, the rainbow serpent, who made Millstream and Fortescue River.	Archaeological material in the form of a multi-platform core (a flaked stone artefact) was identified.
Mitharnu (Woodley Spring)	A beautiful place to visit in the past. The Millstream area is a lush oasis in the broader landscape now, and in the past. The area and places within it, such Mitharnu (Woodley Spring), evoke strong feelings for the Yindjibarndi people.	A place associated with Jirndawurrunha (Millstream Station), a place associated with significant historic themes and specific Yindjibarndi people. Mitharnu is also known as Woodley Spring, a name associated with specific Yindjibarndi people.	A place that people can camp in the past and with the spring described as described the spring as a “giver of life”, finding all the food and fruits to live.	Mitharnu (Woodley Spring) has spiritual value as a place associated with the Rainbow Serpent and a specific story about this significant figure.	Archaeological material in the form of a grinding base fragment was identified during the visit to Mitharnu (Woodley Spring)
Miliyanha (Chinderwarriner pool or Lily pool) and Yundu Thalu Munggu	A place that water can be experienced. The Yindjibarndi representatives described this experience	A place closely associated with Jirndawurrunha (Millstream Station), a place associated with	A meeting place and a place important to specific social functions. The Yindjibarndi representatives said that for old people, places like	A sacred place that plays an important role in their religious practices. In Yindjibarndi	Archaeological material in the form of a dolerite muller (a ground stone artefact)

Location	Aesthetic Values	Historic Values	Social Values	Spiritual Values	Scientific Values
(Rain Increase Termite Mound)	across sight and sound and expressed the feelings it evoked. Kevin Guiness described the flowing water at Miliyanha as, “very relaxing to hear it, [puts one at] ease, feel at home, like a meditation. Think about the old people”.	significant historic themes and specific Yindjibarndi people. The place is historically intertwined with the homestead and this history was discussed by the Yindjibarndi representatives.	Miliyanha were vital social hubs where communities gathered for various activities such as fishing, ceremonial activities (rain making), and storytelling. These gatherings fostered strong social bonds within the community, providing opportunities for connection, cultural exchange, and the passing down of traditional knowledge from elders to younger generations. Elders would pass on wisdom, stories, and traditional ecological knowledge to younger members of the community, ensuring the continuation of cultural heritage and values.	cosmology, Miliyanha is regarded as a sacred waterhole, intricately connected to the Dreaming stories and spiritual beings that shape the land. This pond is said to be the eye of the Barrimirndi, the rainbow snake. It is considered taboo for Yindjibarndi people to swim in the water. Instead, any interaction with the pond must be approached carefully and with rituals speeches and gestures. Yindjibarndi men will sing and tell the thalu where they want it to rain.	was identified during the visit to Miliyanha (Chinderwarriner pool or Lily pool).
Jirndawurrunha (Millstream Station)	A place that evokes strong memories of the past through the experience of the homestead and grounds. The Millstream area is a lush oasis in the broader landscape now, and in the past. The area and places within it, such Jirndawurrunha (Millstream Station),	A place associated with significant historic themes and specific Yindjibarndi people. The homestead is a place established during the colonisation of the north-west of Western Australia and expansion of pastoralism in the	Jirndawurrunha (Millstream Station) is the “capital city, heart of Yindjibarndi” nation. He stated that this place is important because it features “water of life”and represents the “history of creation, how Jirndawurrunha was created by snake [Barrimirndi (rainbow serpent)] ngurranyujangammu (when the world was soft).	Jirndawurrunha (Millstream Station) has spiritual significance to the Yindjibarndi people as a place significant in their belief system and a place related to their religious practices. Jirndawurrunha (Millstream Station) is a sacred place and is	(Millstream Station) has potential scientific value as an ethnographic and historic place. The place may contribute to understandings of Yindjibarndi culture and past and/or the research

Location	Aesthetic Values	Historic Values	Social Values	Spiritual Values	Scientific Values
	evoke strong feelings for the Yindjibarndi people.	area. Pastoralism is a significant historic theme in the past of the Yindjibarndi people, and the Aboriginal people of Western Australia more broadly, with this type of European contact forming a significant historic event in their past and being part of state and nation- wide patterns.	A place that is significant to their community and identity. Jirndawurrunha (Millstream Station) and the place at which it is located has played a number of different roles in the social history of the Yindjibarndi people and has strong meaning to them due to its long history as a place of significance.	associated with a creation narrative. The spiritual values of the Yindjibarndi are expressed in the landscape around Jirndawurrunha (Millstream Station), which is a place and area of great importance to the spiritual health of the Yindjibarndi people.	interests of the Yindjibarndi people.

The Millstream Wetlands are located in the Millstream Chichester National Park. Most of the 240,000 hectares Millstream Chichester National Park is a landscape of rolling spinifex hills, escarpments and winding tree-lined watercourses. Millstream Wetlands and Fortescue River pools provide an oasis in the desert that attract visitors for bushwalking, camping, permanent rivers and pools and to experience of the cultural values to the Yindjibarndi people. The Millstream Homestead now forms the visitor centre to the park.

6.4 Studies and Investigations

- Millstream Abstraction s.38(1) Referral (YAC, 2024).
- Ngurra Warndurala Buluyugayi Exploring Yindjibarndi Country (Juluwarlu Aboriginal Corporation, 2007) (presented as supplementary document 2 in the YAC referral).
- Report of a Cultural Values and Impacts Baseline Survey at Millstream for Yindjibarndi Ngurra Aboriginal Corporation and Yindjibarndi Water (Echoes Cultural Heritage Management, 2024) (presented as supplementary document 3 in the YAC referral).
- Millstream Fluvial Geomorphology Study and Engineering Design Advice Geotechnical Desktop Study (4DGeotechnics, 2024).

6.5 Environmental Values

6.5.1 Yindjibarndi Aboriginal Values

The Yindjibarndi Aboriginal people consider the Fortescue River (Yarnda Nyirranha) as the spine through the heart of Yindjibarndi tribal country. The entire story of the Barrimirndi (i.e. Warlu, Rainbow Serpent) follows the Fortescue River, to the resting place and the permanent pools. The environmental values include the pools and river of the Millstream Wetland and they key pools as outlined in YAC (2024) are:

- Murlurnmun yjurna Wurndu (Crossing pool).
- Mitharnu (Woodley Spring).
- Miliyanha (Chinderwarriner pool or Lily pool) and Yundu Thalu Munggu (Rain Increase Termite Mound).

For the purpose of this social surroundings assessment, all pools identified in the inland water assessment will also be considered environmental values for social surroundings.

The Yindjibarndi Aboriginal people also consider Jirndawurrunha (Millstream Station), burial grounds and other listed archaeological places listed in the ACH register, as places of cultural value.

6.5.2 Other Social Surroundings Values

The Millstream Wetlands are located in the Millstream Chichester National Park. The park attracts approximately 20 000 visitors a year (DEC, 2007). The Millstream Chichester National Park is a Class A reserve, being Crown Reserve 30071. The Parks Australia holds the management order for the reserve.

6.6 Potential Environmental Impacts

6.6.1 Direct

No clearing is proposed and no direct impacts to the Millstream Wetlands and other cultural places are expected as a result of implementation of the proposal.

No impacts are expected to the Millstream Homestead, burial grounds or archaeological sites as the proposal does not include any clearing and the proposal activities are limited to groundwater abstraction.

6.6.2 Indirect

The cultural values of the Millstream Wetlands may be indirectly impacted by groundwater abstraction altering the volume of the springflow from the aquifer entering Millstream Wetlands pools and rivers.

The YAC (2024) referral states that pool water levels are in decline and presents graphs showing a percentage of mean frequency and a monitoring period from 2013 to 2023. Figure 25 and Figure 26 presents the Corporation data showing a longer timeframe of monitoring with recorded water level readings (presented as mAHD).

The change to pool water levels at Deep Reach pool has been within approximately a 1m range, with levels recorded at 292.61 mAHD in 2006 to 291.53 mAHD in 1988, with the exception of the period of 1979 to 1982 when abstraction reached 16GL/a. The pool water levels are erratic, characterised by 0.5m peaks associated with tropical cyclones and lows feeding the Fortescue River during the wet season. Figure 25 shows that in recent years, the peaks are not as variable, reflecting a more median trend in rainfall, but the overall trend is consistent with pools levels since 1990. The most recent reading of 291.92 mAHD in January 2025 is generally consistent with the pool levels since 1990 (291.86 mAHD in 1990).

The pool water levels at Chinderwarriner pool have ranged by around 0.2m from 293.13 mAHD in 1989 to 293.32 mAHD in 2006, with the exception of the period of 1981 to 1985 when abstraction reached 16GL/a. Monitoring at Chinderwarriner pool ceased in 2014 and was replaced with monitoring from bore 1E (Figure 26). Groundwater levels peaked in 2000 due to tropical cyclone Steve and 2006 due to tropical cyclone Clare followed by tropical cyclone Emma C1 (largest recorded recharge event). The pool levels as measured at bore 1E have since receded to levels observed prior to these events.

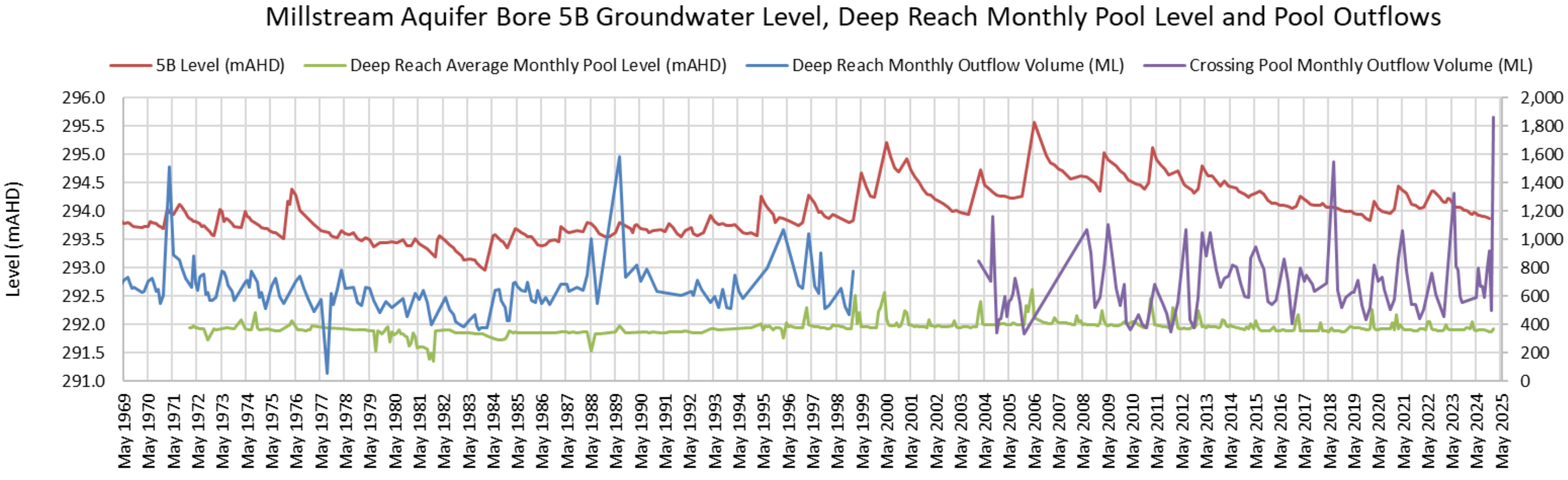


Figure 25: Deep Reach pool levels

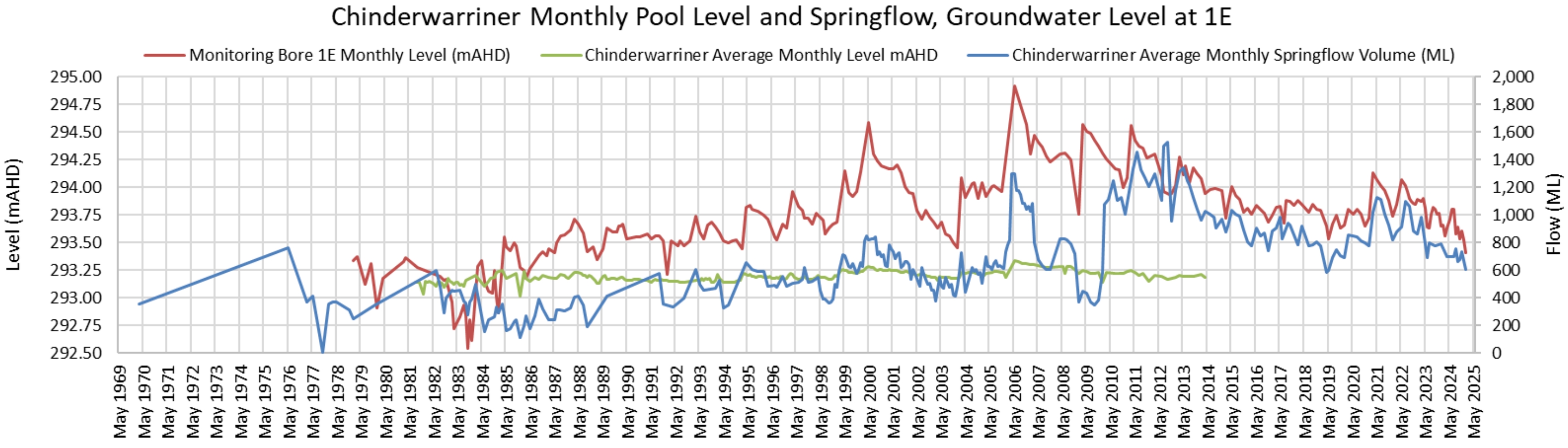


Figure 26: Chinderwarriner pool levels

The average discharge volumes from the Millstream aquifer to Deep Reach pool observed at Crossing pool between 2014 to 2024 is 7.9GL/a, Chinderwarriner pool is 10.2GL/a, and small springs west of Chinderwarriner pool including Woodley, Peters, and Palm Creeks is estimated discharge 0.23GL/a (Water Corporation, 2024). Given the average annual flow into the Millstream Wetland pools from the Fortescue River (recorded at DWERs downstream Gregory Gorge gauging station) for the 2014 – 2024 period was on average 115.5GL/a, springflow from the Millstream aquifer therefore presents almost 16% of total flow recorded at Gregory Gorge with water sourced from the Fortescue River presenting just over 84%.

Any lowering of the watertable due to the proposal is not likely to impact water levels in Deep Reach and Chinderwarriner pools as the main water source for these pools is flow through the Fortescue River which is a system reliant on rainfall generated runoff from tropical cyclones and lows during the wet season.

Livistona, Palm and Crossing pools are fed by surface water moving through the Fortescue as well as springflow generated overflow from Deep Reach pool and tributaries such as Chinderwarriner. Any water level decline in these pools cannot be solely attributed to the proposal and may be attributed to other factors, such as local hydroclimatic conditions.

The pools at Woodley, Peters and Palm Creek are fed from low background volumes of springflow from the aquifer and from runoff generated by significant climatic inputs. Any reduction in springflow attributed by the proposal is not likely to impact the water levels in the pools, as background volumes are low and pools levels are likely to be supplemented by catchment runoff.

Erosion

YAC (2024) discussed the impacts from erosion on the Millstream Wetlands, including the pools. In response to the ongoing focus on erosion by the MHCC and TWG, the Corporation commissioned a fluvial geomorphology study for the section between Deep Reach and Crossing pools (4DGeotechnics, 2024).

The development of erosion channels between the various pools (downstream of Deep Reach, Crossing and Chinderwarriner pools), forming relatively steep stream bed intervals, that continue to erode upstream, have been an ongoing issue since the mid-1960s. The erosion occurs in stages, commencing with sheetwash, initial channel development and entrenched upper channels within the alluvium soils until channels form where calcrete (Millstream aquifer) is exposed at the base of the channels.

The cause of channel development and erosion at the overflow point at Deep Reach pool is due to erosion of the alluvial soils. The underlying Millstream aquifer calcrete and Marra Mamba formation are less permeable, causing the runoff to erode the softer alluvium, resulting in exposure of the underlying watertable Figure 27. This is considered a natural process, exacerbated by fire and hydroclimatic conditions and not attributed to the proposal.

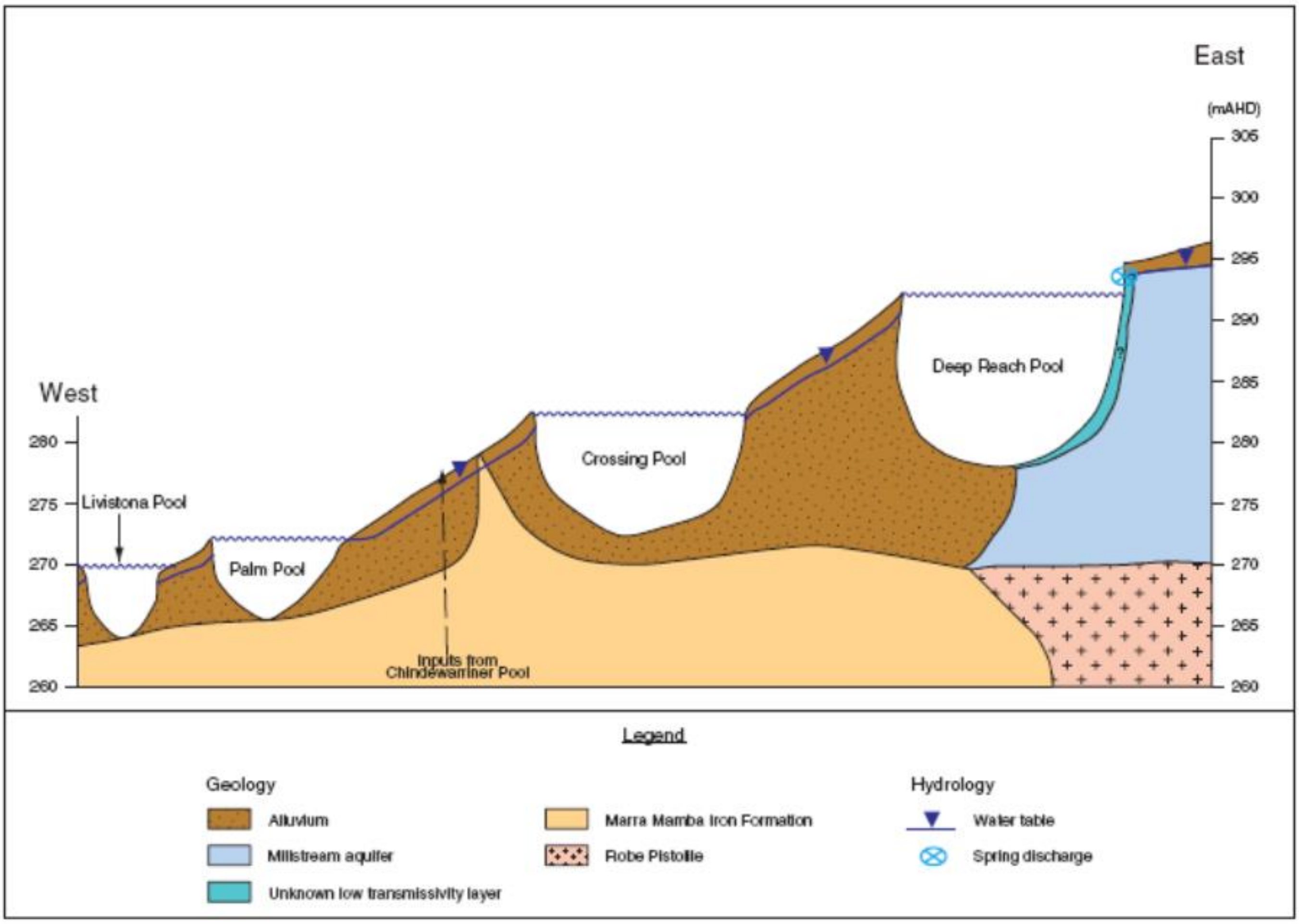


Figure 27: Cross section of the pools along the Fortescue River

6.7 Mitigation

The minimisation and management measures to minimise and mitigate impacts to springflow into the Millstream Wetlands and pools are presented in the WRMOS (Appendix B). The responses outlined in the WRMOS are discussed in the Inland Waters chapter.

The Corporation will continue to consult with key stakeholders including YAC for ongoing operations and management of the proposal.

6.8 Assessment and Significance

Potential impacts and observations to pool and river levels within the Millstream Wetlands are not solely directly related to groundwater abstraction as a result of implementation of the proposal. Any observed impacts are likely to be caused by drying hydroclimatic conditions including periods without significant rainfall-runoff and recharge. The pool water levels in Millstream aquifer directly correlate to the Fortescue River flows, supplemented by springflow from the Millstream aquifer during the dry season and failed wet seasons. Overall annual springflow representing around 16.3% of water source into the pools over a median climate period (the last 10 years).

Previous abstraction volumes and monitoring data have shown groundwater abstraction volume greater than 9.5GL/a (up to 16GL/a) over a 7-year period resulted in impacts at Deep Reach and

Chinderwarriner pools. These impacts are not expected given the proposal is for abstraction below 9GL for a period of 2 years. No long-term significant impacts to pool water levels are expected.

For Social Surroundings to be considered significant, there must be significant impacts to pool water levels, vegetation health and soil erosion; and for these impacts to directly and significantly effect heritage values, being the aesthetic, historical, social, spiritual or scientific values of the site. The observations to pool water levels, vegetation health and soil erosion are not considered significant impacts attributed to the proposal. The assessment of significance is considered not significant, as the observed pool water levels, vegetation health and soil erosion are not attributed to the proposal and likely due to climatic conditions.

6.9 Environmental Outcomes

The observed and future potential changes to culturally important pool levels within the Millstream Wetlands are primarily due to antecedent hydroclimatic conditions and are not significant, nor directly related to groundwater abstraction. Groundwater abstraction is not a clear direct link to observations to pool and river levels within the Millstream Wetlands and these observations are not considered significant affects. The proposal is not likely to result in significant impacts to cultural values and the EPA objective "*To protect social surroundings from significant harm*" can be met.

7. Flora and Vegetation

7.1 EPA Environmental Factor and Objective

The objective of the EPA (2016) Environmental Factor Guideline Flora and Vegetation is:

To protect flora and vegetation so that biological diversity and ecological integrity are maintained.

7.2 Relevant Legislation, Policy and Guidance

- Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023).
- Environmental Factor Guideline - Flora and Vegetation (EPA, 2016).
- Technical Guidance Flora and Vegetation Surveys for Environmental Impact Assessment (EPA, 2016).
- Approach to vegetation monitoring in the Pilbara – West Pilbara Water Supply Scheme. (DoW, 2013).
- Approach to vegetation monitoring in the Pilbara – guidance for proponents (DoW, 2024) (updated).
- *Biodiversity Conservation Act 2016* (BC Act).
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

7.3 Receiving Environment

The Millstream Wetland is listed in the Directory of Important Wetlands in Australia (Environment Australia 2001). The Millstream Wetland is partly within the Millstream-Chichester National Park, and whilst it has been nominated for listing under the Ramsar Convention on Wetlands (DEC, 2007) it is not currently listed as a Ramsar wetland.

The riparian communities of springs and Pools Pilbara (P2) Priority Ecological Community (PEC) is associated with the Millstream Wetland. The Millstream Wetland is not a listed threatened ecological community (TEC) and there are no other TECs in proximity to the proposal.

The results from the government databases DBCA-036 (DBCA, 2022) and DBCA-038 (DCBA, 2025) and Protected Matters Search Results for the abstraction area and the Millstream Wetlands area (Figure 28), are:

- No Threatened Flora under the BC Act or EPBC Act.
- Priority (P) flora within the Millstream Wetland area:
- *Cladium procerum* (P2) and *Teucrium pilbaranum* (P2).
- *Swainsona thompsoniana* (P3), *Goodenia obscurata* (P3), *Fimbristylis sieberiana* (P3) .
- *Themeda sp. Hamersley Station* (M.E. Trudgen 11431) (P3), *Triodia pisoliticola* (P3) .
- *Livistona alfredii* (P4) .
- Priority Ecological Communities
- Riparian communities of springs and Pools Pilbara (P2) PEC .
- Kanjenjie Land System (P3) PEC (2.5km to the south of the borefield).

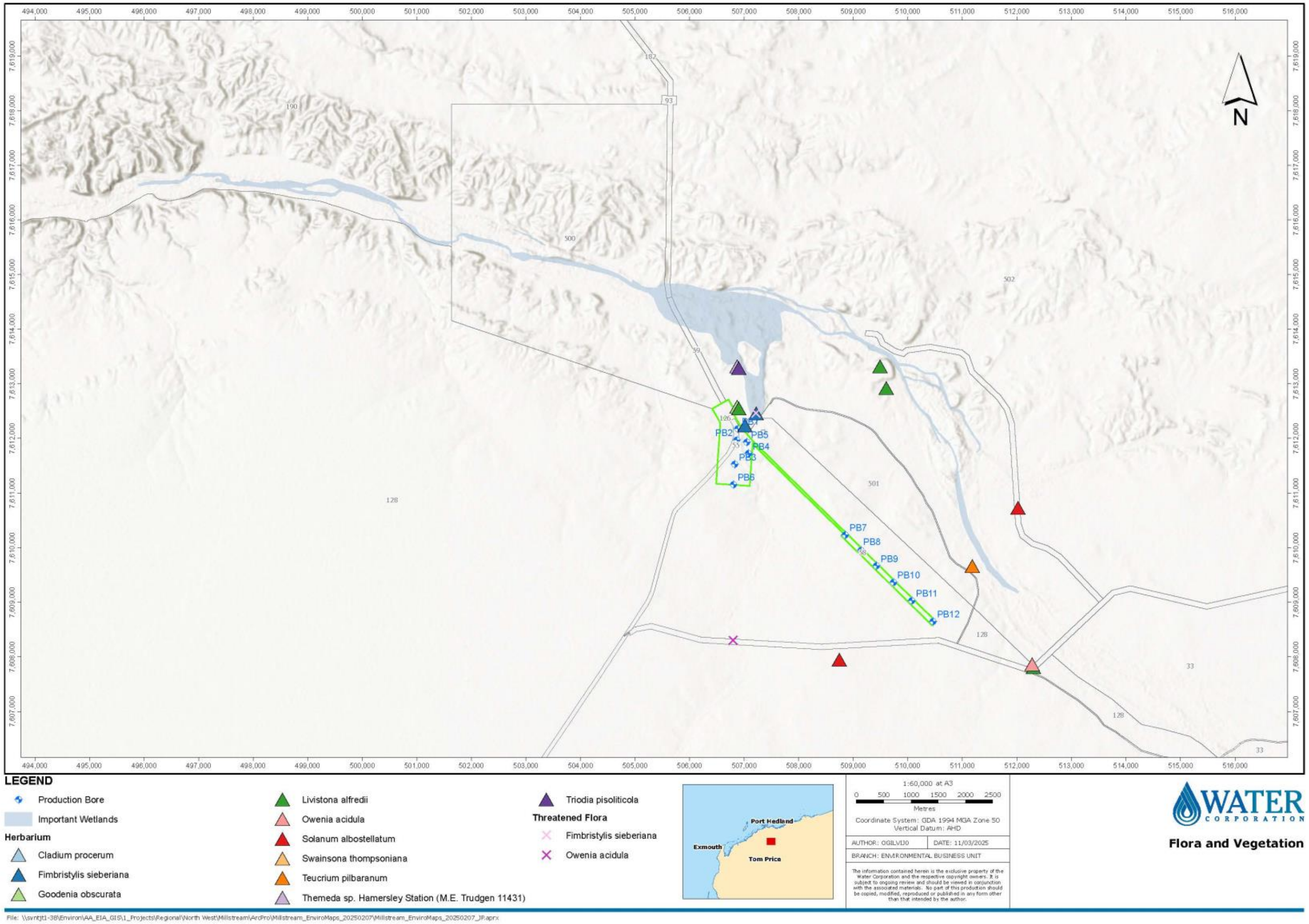


Figure 28: Flora and Vegetation

The vegetation associated with the Millstream Wetlands and pools contains (Braimbridge et al., 2010):

- a diverse assemblage of vegetation communities including 12 considered to be groundwater dependent (Table 14) and some that are restricted in their distribution to the region, and
- at least 125 taxa of vascular flora from 39 families.

Mapping of vegetation communities was completed by Dames and Moore (1984). The survey resulted in 22 structural/floristic vegetation communities for the area, of which 17 occur in the river bed/stream channels and 12 potential groundwater dependent vegetation (GDV) communities (Table 14) and as shown in Figure 29. GDV is vegetation with direct access to groundwater and/or vegetation that is 'fed' by groundwater derived discharge.

Table 14: Groundwater dependent vegetation communities in the Millstream area

Description	Other species which may be present
Woodland of *Livistona alfredii* with *Eucalyptus camaldulensis* over *Acacia* spp. shrubland.	*Acacia ampliceps, Acacia trachycarpa, Gossypium robinsonii, Cynodon dactylon, Cyperus vaginatus, Melaleuca glomerata*
Woodland of *E. camaldulensis* and *Melaleuca argentea* over shrubland of *Acacia ampliceps* and *Stylobasium spathulatum* over *Cyperus vaginatus.*	*Acacia sclerosperma, Acacia trachycarpa, Hibiscus panduriformis, Petalostypis labichioides*
Open woodland of *E. camaldulensis* over open shrubland of *Acacia ampliceps* over *Cynodon dactylon*	
Very open woodland of *Eucalyptus xerothermica* over mixed open shrubland	*Acacia bivenosa, Acacia holorsericea, Acacia ligulata, Acacia sclerosperma, Cenchrus cilliaris, Ptilotus obovatus, Senna notabilis, Solanum lasiophyllum, Triodia wiseana, Waltheria indica*
Shrubland of *Melaleuca glomerata* with *A. ampliceps* over *C. dactylon* with occasional emergent *E. camaldulensis.*	*Acacia bivenosa, Melaleuca bracteata, Triodia wiseana*
Shrubland of *Melaleuca bracteata* with emergent *M. argentea* and *E. camaldulensis* over sedges *Typha domingensis* and *Baumea juncea*	*Acacia ampliceps, Cynodon dactylon, Pimelea ammocharis, Stylobasium spathulatum*
Woodland of *E. camaldulensis* over closed shrubland *A. ampliceps*, *M. bracteata*, *Stylobasium spathulatum* and *Gossypium robinsonii*	*Acacia bivenosa, Acacia farnesiana, Cenchrus ciliaris, Cynodon dactylon, Cyperus vaginatus*
Grassland *Cynodon dactylon* with open shrubland of *A. ampliceps* and occasional emergent *E. camaldulensis*	
Closed shrubland of *S. spathulatum*, *Eremophila longiflora* and *A. ampliceps*	*Typha domingensis, Baumea juncea, Senna glutinosa, Cynodon dactylon, Melaleuca glomerata, Acacia ampliceps*
Forest *E. camaldulensis* and *L. alfredii* over closed shrubland of *Acacia ampliceps*, *Acacia trachycarpa* and *Cyperus vaginatus*	*Acacia sclerosperma, Acacia farnesiana, Juncus* sp.
Very open woodland *E. Camaldulensis*	
Creekline woodland of *E. camaldulensis* and *Eucalyptus victrix* over mixed shrubland	*Acacia holorsericea*

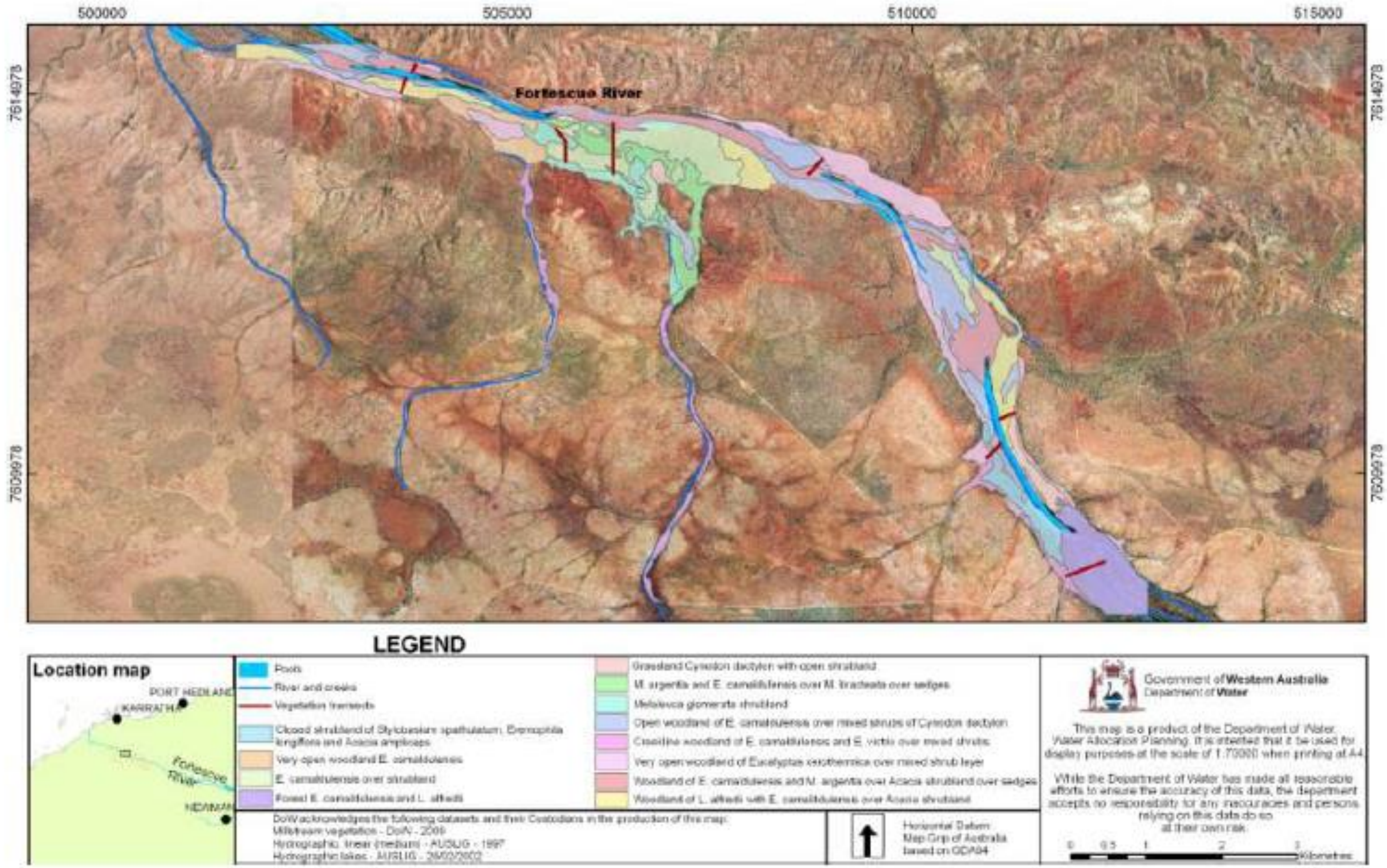


Figure 29: Groundwater dependent vegetation communities for the Millstream area (Braimbridge et al, 2010).

7.4 Studies and Investigations

- Braimbridge, M, Antao, M and Loomes, R, 2010, Groundwater dependent ecosystems for Millstream: ecological values and issues, Environmental water report series, Report no. 13, Department of Water, Government of Western Australia, 2010).
- Millstream Vegetation monitoring program. Canopy photography baseline survey results (DoW, 2013).
- Millstream Riparian Vegetation Remote Sensing Technical and Data Delivery Report 2013 (DPaW, 2014).
- Millstream Riparian Vegetation Remote Sensing Vegetation Monitoring Report 2015 (DPaW, 2015).
- Millstream Riparian Vegetation Remote Sensing Vegetation Monitoring Report 2016 (DPaW, 2016).
- Millstream Riparian Vegetation Remote Sensing Vegetation Monitoring Report 2017 (DPaW, 2017).
- Millstream Riparian Vegetation Remote Sensing Vegetation Monitoring Report 2018 (DPaW, 2018).
- Millstream Riparian Vegetation Remote Sensing Vegetation Monitoring Report 2019 (DPaW, 2019).
- Millstream Vegetation Condition Monitoring (GHD, 2022).
- Millstream Borefield Millstream Vegetation Condition Monitoring 2019 Assessment (360 Environmental, 2020)
- Millstream Vegetation Condition Monitoring 2017 Results (GHD, 2018).

7.5 Environmental Values

GDV of the Millstream Wetlands, including the Fortescue River and delta channels, including:

- Riparian communities of springs and Pools Pilbara (P2) PEC.
- 12 groundwater dependent vegetation communities.
- Priority flora species have also been recorded in the Millstream Wetland area.

7.6 Potential Environmental Impacts

7.6.1 Direct

The proposal comprises the abstraction from existing production bores. No clearing of vegetation is required for this proposal and no direct impacts to flora and vegetation are proposed.

7.6.2 Indirect

The riparian, riverine and delta vegetation, and priority flora associated with the Millstream Wetlands, may be indirectly impacted by groundwater abstraction altering the volume of the springflow from the aquifer entering Millstream Wetlands pools and rivers.

Discharge from the aquifer via springflow into the Millstream Wetlands pools, and subsequent overflow into the Fortescue River and delta channels respectively, sustains riparian and wetland vegetation.

Potential indirect impacts to groundwater dependant vegetation can be assessed using historical monitoring results as an indication of future abstraction impacts. Target levels for aquifer riparian vegetation are based on groundwater level criteria as outlined in Table 15. The criteria to be used based on the recharge class (Table 10).

Table 15: Groundwater level criteria to support aquifer riparian vegetation

Recharge class		MAL (average groundwater level at 8 bores)
1	5th percentile drought criteria	≥293.50 mAHD
1	15th percentile drought criteria	≥293.57 mAHD
2	20% percentile dry criteria	≥293.60 mAHD
3	50th percentile average/wet criteria	≥293.80 mAHD

Figure 30 shows that the MAL is generally above the criteria since 1999. It has remained above the criteria to present date and has increased by 0.6m since 1980’s. The criteria was reached in the 1980’s due to abstraction greater than 9GL/a. Since 1998 the MAL has recovered and increased above the riparian vegetation criteria to the current level of 293.81 in November 2024.

Separate criteria have been derived for riverine and delta vegetation.

Riverine and delta vegetation is supported by local groundwater levels largely recharged by pool outflows and flow down the Fortescue River. Because these levels can be influenced by several other factors (e.g. evaporation, floods, fires, and national park management), local groundwater criteria have been set in addition to pool outflow rates. These criteria are still being aligned to correspond with vegetation condition and are considered to be observation levels until a closer relationship is determined. Any actions in relation to the observation levels is to be determined through the TWG.

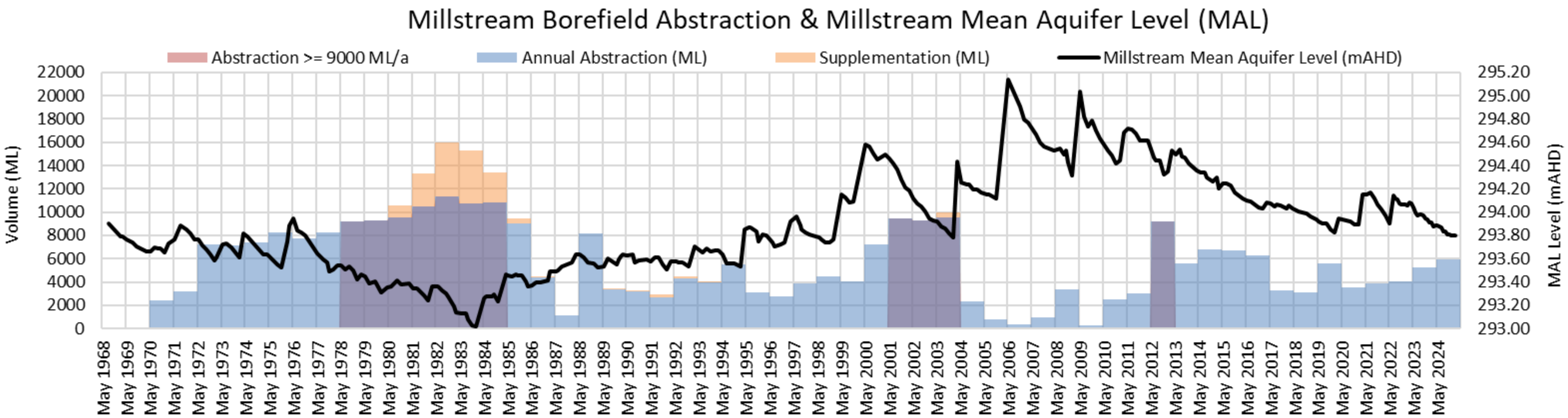


Figure 30: Millstream MAL and historical groundwater abstraction volumes

The primary target levels for springflow to protect riverine and delta vegetation is outlined in Table 8 and are based on the recharge class (Table 10), the local observational riverine and delta vegetation criteria are outlined in Table 16. These triggers and criteria are fixed and do not vary with recharge classes.

Table 16: Riverine and delta vegetation criteria using groundwater levels

Applicable criteria	5th percentile drought criteria	20% percentile dry criteria	50th percentile average/wet criteria
P10 (Riverine)	≥270.07mAHD	≥270.28mAHD	≥270.70mAHD
P7/77(Riverine)	≥290.46mAHD	≥290.70mAHD	≥291.02mAHD
03/04 (Delta)	≥285.76mAHD	≥285.81mAHD	≥285.86mAHD
12/04 (Delta)	≥283.96mAHD	≥284.14mAHD	≥284.27mAHD
04/04 (Delta)	≥287.32mAHD	≥287.43mAHD	≥287.65mAHD
P2/77 (Delta)	≥278.70mAHD	≥279.28mAHD	≥279.73mAHD
P3/77 (Delta)	≥278.01mAHD	≥278.20mAHD	≥278.35mAHD
P4/78 (Delta)	≥283.22mAHD	≥283.51mAHD	≥283.79mAHD
Palm Springs P2	≥278.74mAHD	≥278.80mAHD	≥278.93mAHD

The rate of spring discharge pool needed to support riverine and delta vegetation has been calculated (Table 17), using evapotranspiration demand (ET_G). During periods of permanent flow from Deep Reach pool through to Gregory Gorge, ET_G demand, minus rainfall inputs, is estimated at 7.165GL/a or 0.277 kL/s (Table 17). This is representative of ET_G demand during average to wet conditions.

Table 17: ETg for the Riverine area between Deep Reach pool and Gregory Gorge

Area	Linkage	Yearly ET_G (GL)	ET_G (kL/s)
Riverine: Deep Reach to Livistona	Permanent flow	5.455	0.173
Riverine: Livistona to Gregory Gorge	Intermittent flow	2.306	0.073
Rainfall recharge		-0.595	-0.019
Total		7.165	0.227

The water requirements for riverine and delta vegetation are sourced from springflow from Deep Reach pool and other water sources, such as direct rainfall and surface runoff from Millstream and via the Fortescue River during significant climatic events climatic events.

Table 18 presents the ET_G requirements for the riverine vegetation compared to the spring discharge volumes from Deep Reach pool. The requirements for riverine (ET_G) is greater than the spring discharge volumes for Deep Reach pool, to account for the supply of direct rainfall recharge and additional surface water from the 13,800 km^2 Fortescue River catchment and Millstream system (DWER, 2019).

Any impacts to riverine and delta vegetation from a reduction to the springflow from Deep Reach pool cannot be solely attributed to the proposal. The health of the riverine vegetation demonstrably influenced by a range of influences including direct rainfall and surface runoff.

Table 18: ET_G demand of downstream riparian vegetation during wet, dry and drought water availabilities

Water availability	ETG Deep Reach pool to Gregory Gorge	Period of no flow Livistona to Gregory Gorge	Reduced spring discharge Livistona to Gregory Gorge	ETG adjusted for water availability	Deep Reach spring discharge thresholds
Wet	0.227 kL/s	0	0	0.227 kL/s	0.265 kL/s
Dry	0.227 kL/s	0.25 (3 months)	0.73 * 0.25 = 0.018 kL/s	0.209 kL/s	0.225 kL/s
Drought	0.227 kL/s	0.50 (6 months)	0.73 * 0.5 = 0.036 kL/s	0.191 kL/s	0.199 kL/s

Figure 31 shows the rate of spring discharge at Deep Reach pool needed to support riverine and delta vegetation. Observed spring discharge fluctuates and has historically recorded values well below the current thresholds.

Vegetation conditions assessments in 2017, 2019 and 2021 indicate no tangible long-term impacts directly attributable to the fluctuations in discharge, this indicates that downstream vegetation is accessing sufficient water. This suggests that the current combination of springflow, direct rainfall and surface water runoff from the Millstream and Fortescue systems is sufficient to maintain vegetation health.

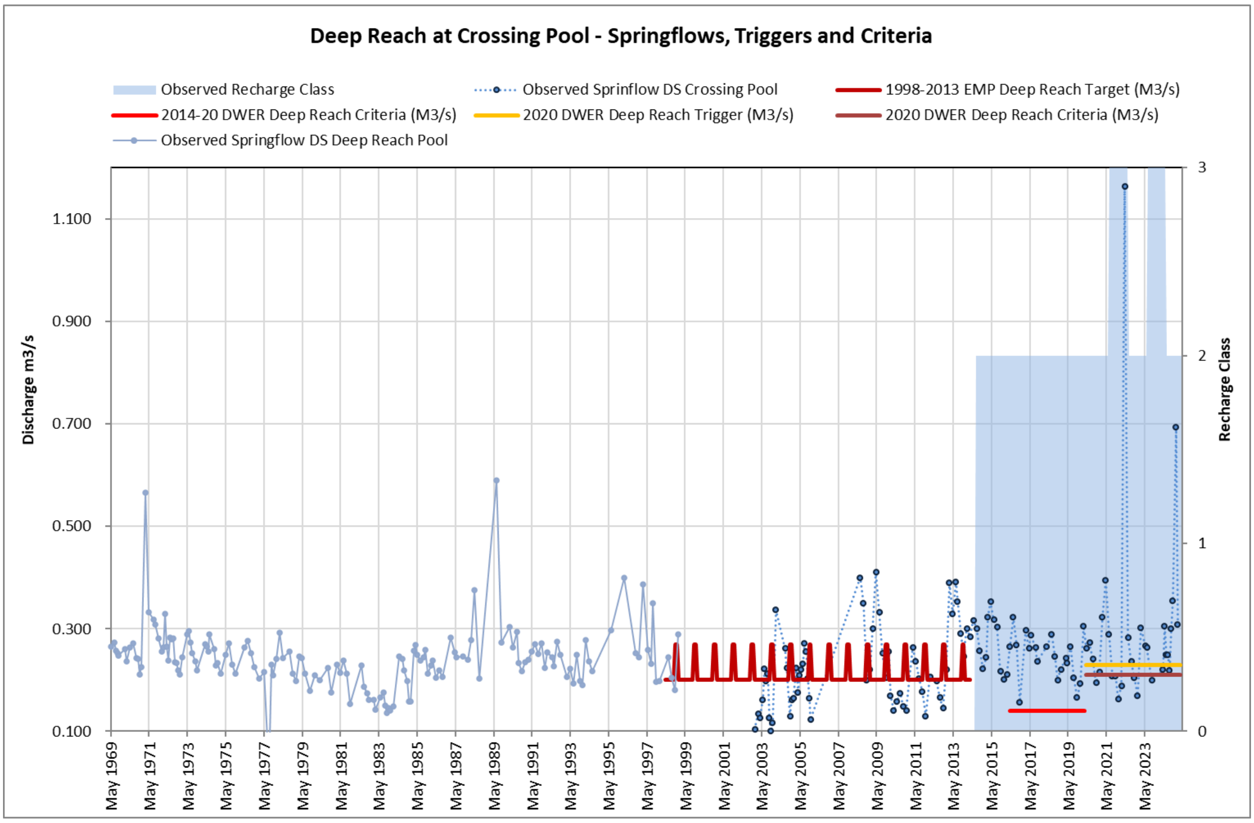


Figure 31: Springflow, Measured as Outflow from Deep Reach pool 1969-1999 and Crossing pool 2003 - 2025

The ET_G required for delta vegetation is presented in Table 19 (DWER, 2019).

Table 19: Calculated ETG for the Delta area between Chinderwarriner pool and Fortescue River

Area	Yearly ETg (GL)	ETg kL/s
Millstream delta	4.713	0.149
Rainfall recharge	-0.226	-0.007
Total	4.488	0.142

The water requirements for delta riparian vegetation are sourced from both springflow volumes from Chinderwarriner pool and other water sources, such as direct rainfall and surface runoff from Millstream during significant climatic events.

Table 20 presents the ET_G requirements for the delta riparian vegetation compared to the spring discharge volumes from Chinderwarriner pool. The requirements for delta riparian vegetation (ET_G) is greater than the springs discharge volumes for Chinderwarriner pool, indicating the criteria account for the provision of additional water, such as surface runoff from Millstream during significant climatic events (DWER, 2019).

With discharge from Chinderwarriner occurring at levels much higher than historically observed and vegetation conditions assessments in 2013, 2017, 2019 and 2021 indicating no tangible long-term impacts directly attributable to the fluctuations in discharge this suggests the vegetation is accessing sufficient water. This suggests that the current combination of springflow, direct rainfall and surface water runoff from the Millstream and Fortescue systems has been sufficient to maintain vegetation health.

Any impacts to delta riparian vegetation due to a reduction to the springflow from Chinderwarriner pool cannot be solely attributed to the proposal. The health of the delta riparian vegetation has been demonstrated to be influenced by a range of other influences including access to direct rainfall and surface runoff from Millstream.

Table 20: Calculated ETG demand of delta riparian vegetation compared to Chinderwarriner spring discharge thresholds

Water condition	Calculated ETg demand (kL/s)	Spring discharge thresholds (kL/s)
Wet	0.142 kL/s	0.21 kL/s
Dry	Not calculated	0.15 kL/s
Drought	Not calculated	0.11 kL/s

Figure 32 shows the rate of spring discharge at Chinderwarriner pool needed to support riverine and delta vegetation was predominately above criteria since 1999 (with the exception of 2010 where the data is considered of a low quality due to the loss of the measurement structures during a large localised rainfall event) to current discharge of 0.226 m3/s in January 2025. Historic springflow records show that outflow levels have been observed at levels lower than the EMP criteria set in 1999, however vegetation conditions assessments in 2013, 2017, 2019 and 2021 indicate no tangible long-term impacts directly attributed to these periods of lower flow, suggesting vegetation is likely accessing sufficient water. This indicates that the current combination of springflow, direct rainfall and surface water runoff from the Millstream system has been sufficient to maintain vegetation health.

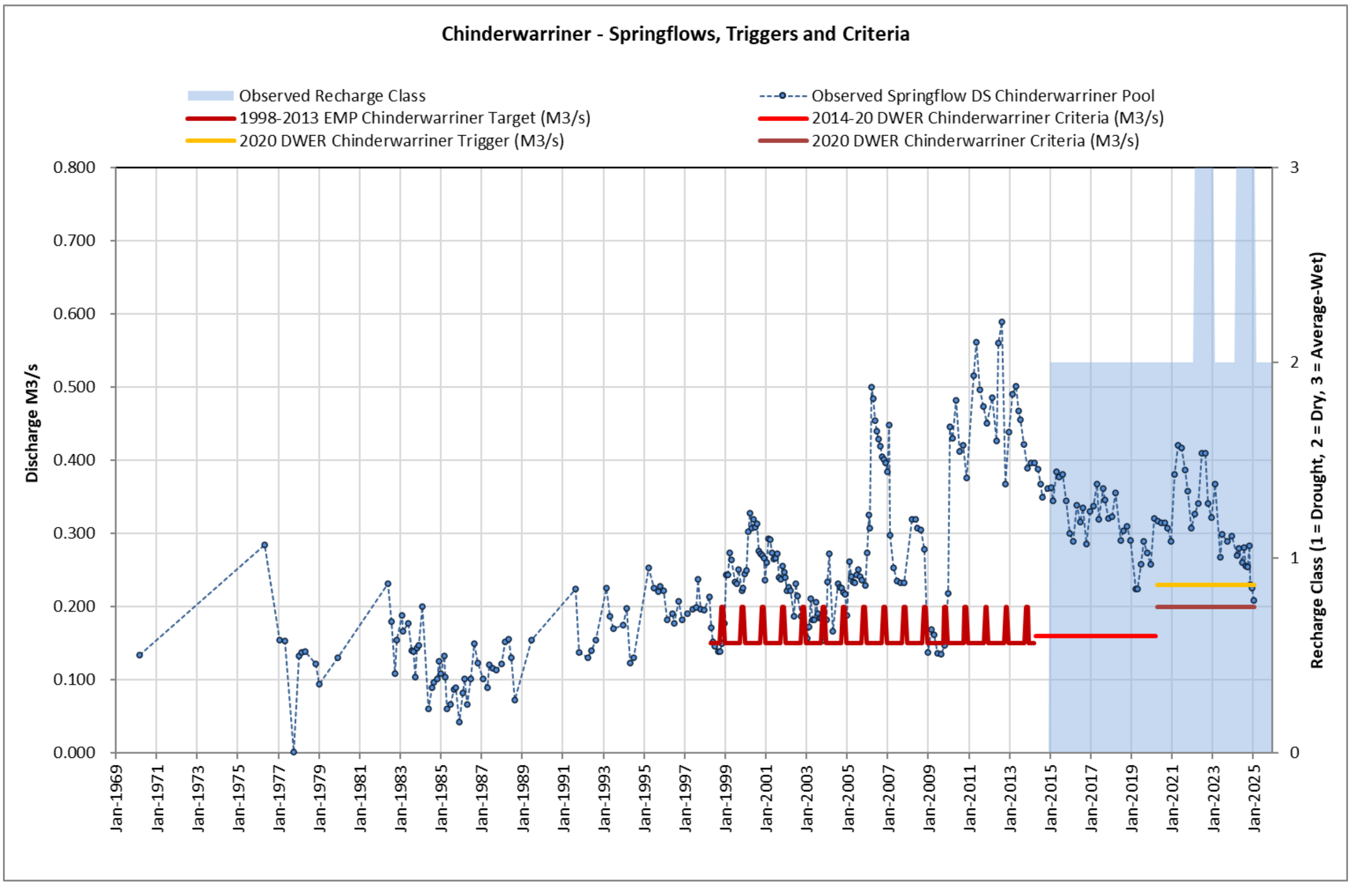


Figure 32: Springflow, Measured as Outflow from Chinderwarriner pool.

Vegetation health monitoring had been undertaken as a response measure. Baseline assessments undertaken by DoW in 2013 and follow-up surveys have been completed in 2017, 2019 and 2021 in accordance with DoW's recommended approach.

In 2020, 360 Environmental used a Kruskal Wallis test in order to determine any significant differences between the 2019 and 2017 data. The results of the Kruskal Wallis test indicated that Canopy Condition Score and Insect Score did not significantly differ from the 2017 Vegetation Condition Assessment. All transects showed species regeneration, with the exception of transect A, where a total of 10 individuals had deceased between 2017 and 2019. The 2019 survey identified impacts from a recent fire.

The 2021 survey found the condition of transects has either remained consistent or increased between 2017 and 2021, with the exception of Transect A in the Woodley Delta which had declined from Good to Poor. In 2019, 360 Environmental noted that the community structure within this transect had "significantly changed compared to 2017 due to a recent fire event". In 2021 GHD noted that "vegetation the community structure was similar to that reported in 2017" indicating that it is slowly returning to its pre-fire state, with the exception of seven Melaleuca glomerata which were likely to have been burnt in the fire.

7.7 Mitigation

The minimisation and management measures to minimise and mitigate impacts to riparian vegetation and GDVs from springflow into the Millstream Wetlands and pools are presented in the WRMOS (Appendix B). The adaptive management measures and response mitigation measures are outlined in the WRMOS are discussed in the Inland Waters chapter and presented in Appendix B.

7.8 Assessment and Significance

The water requirements for riverine and delta vegetation are sourced from both springflow volumes and other water sources, such as direct rainfall and surface water runoff. The requirements for riverine and delta vegetation (ET_G) are greater than the springflow Trigger and Criteria volumes determined by DWER, indicating that the additional water supply, such as direct rainfall and surface runoff from the Fortescue River and Millstream are also required to meet ET_G demand. Any impacts to riverine and delta vegetation from a reduction to the springflow cannot be solely attributed to the proposal given the riverine and delta vegetation requires a combination of water source to meet demand.

As discussed in the Inland Waters section, pool levels within the Millstream Wetlands are not solely directly related to groundwater abstraction and pool water levels are predominantly fed by surface runoff from the Fortescue River and Millstream.

Vegetation health monitoring has been undertaken as a contingency measure. Vegetation health monitoring has shown the condition of transects has either remained consistent or increased between 2017 and 2021, with the exception of Woodley Delta which has declined was burnt following the 2017 survey. Vegetation health monitoring also noted fires at a number of transects in 2019. The decline in the Woodley Delta cannot be directly attributed to abstraction but is likely due to the impact of fire. Given the condition of all other transects has either remained consistent or increased between 2017 and 2021, it is unlikely that the historical breaches in criteria have impacted vegetation health.

7.9 Environmental Outcomes

The observed and future potential impacts on riverine and delta vegetation within the Millstream Wetlands are primarily due to local water availability as well as the acute impacts from fire and floods. The local water availability is strongly correlated with antecedent hydroclimate including direct rainfall, surface water runoff and springflow from the aquifer. Groundwater abstraction from the proposal is not expected to significantly impact the riparian and riverine and delta vegetation within the Millstream Wetlands given the riverine and delta vegetation requires a combination of sources to meet demand. Impacts to riverine and delta vegetation from a reduction to the springflow cannot be solely attributed to the proposal. Implementation of the proposal is not expected to result in significant impacts to flora and vegetation and it is expected that the EPA objective "*To protect flora and vegetation so that biological diversity and ecological integrity are maintained*" can be met.

8. Terrestrial Fauna

8.1 EPA Environmental Factor and Objective

The objective of the EPA (2016) Environmental Factor Guideline for Terrestrial Fauna is:

To protect terrestrial fauna so that biological diversity and ecological integrity are maintained.

8.2 Relevant Policy and Guidance

- Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023).
- Environmental Factor Guideline - Terrestrial Fauna (EPA, 2016).
- Technical Guidance - Terrestrial vertebrate fauna surveys for environmental impact assessment (EPA, 2020).
- *Biodiversity Conservation Act 2016* (BC Act).
- *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

8.3 Receiving Environment

The Millstream Wetlands contain a diverse range of aquatic habitats that support a high diversity of biota. The habitats present include:

- Deep permanent pools
- Shallow permanent and temporary pools
- Permanently fast-flowing sections of channel with gravel substrate
- Slow-flowing channels with organic-rich silt and clay substrates

Sampling of aquatic invertebrates and fish has been conducted at Millstream by Burbidge (1971), Charlton (1994), Masini (1988), Beesley (2006), Morgan et al. (2003) and Pinder and Leung (2009) and summarised in Braimbridge et al, (2010).

Millstream's permanent pools support an assemblage of fish fauna that is abundant and diverse by Pilbara standards (May & McKenzie, 2002). Nine species of freshwater fish (out of a total of 10 recorded for the Fortescue River) and one saltwater species have been recorded (Burbidge, 1971; Morgan et al., 2003; Beesley, 2006). The relatively high number of species recorded for Millstream is likely due to the pools' permanency or stability (Beesley, 2006; Burbidge, 1971). The complexity or diversity of habitats within the pools also contributes to the high number of species present (Beesley, 2006) (as reported in in Braimbridge et al, 2010).

A number of vertebrate fauna rely on groundwater-fed wetlands or groundwater-dependent vegetation for habitat, such as reptiles and amphibians.

The government databases DBCA-037 (DBCA, 2024) and Protected Matters Search Results for the abstraction area and the Millstream Wetlands area, record species known or likely to occur (Figure 33):

- Northern Quoll *(Dasyurus hallucatus)*, Threatened (Endangered) under the EPBC Act
- Grey Falcon *(Falco hypoleucos)*, Threatened (Vulnerable) under the EPBC Act

- Pilbara Leaf-nosed Bat *(Rhinonicteris aurantia (Pilbara form))*, Threatened (Vulnerable) under the EPBC Act
- Ghost Bat (*Macroderma gigas)* Threatened (Vulnerable), under the EPBC Act
- Pilbara Olive Python *(Liasis olivaceus barroni)*, Threatened (Vulnerable) under the EPBC Act
- Common sandpiper (*Actitis hypoleucos*) Threatened Migratory
- Gane's blind snake (Pilbara) (*Anilios ganei*) priority (P) 1 under the BC Act
- Pilbara threadtail (*Nososticta pilbara*) (P2) under the BC Act
- Pilbara dragonfly (*Antipodogomphus hodgkini*) (P3)
- Northern short-tailed mouse, Lakeland Downs mouse, (*Kerakenga Leggadina lakedownensis*) (P4) under the BC Act
- Fortescue grunter (*Leiopotherapon aheneus*) (P4) under the BC Act

An additional three priority fauna were recorded from the project area as being predominantly found in habitats associated with or near permanent water or watercourses (Braimbridge et al, 2010):

- Star finch *(Neochnia ruficauda subclarescens*) P4
- Flock bronzewing *(Phaps histronica*) P4
- Skink (*Notoscinus butleri)* P4

Millstream also provides habitat for a diverse bird assemblage. Of the 146 species recorded for the Millstream-Chichester National Park:

- 38 are waterbirds, many of which are uncommon in inland parts of the Pilbara.
- 31 are listed as migratory species and/or are covered under various international conventions or agreements (DEC, 2007).

Eight species of waterbirds are known to use the area for breeding. The riparian/wetland eucalypt and melaleuca forests provide important habitat for many of the bird species recorded.

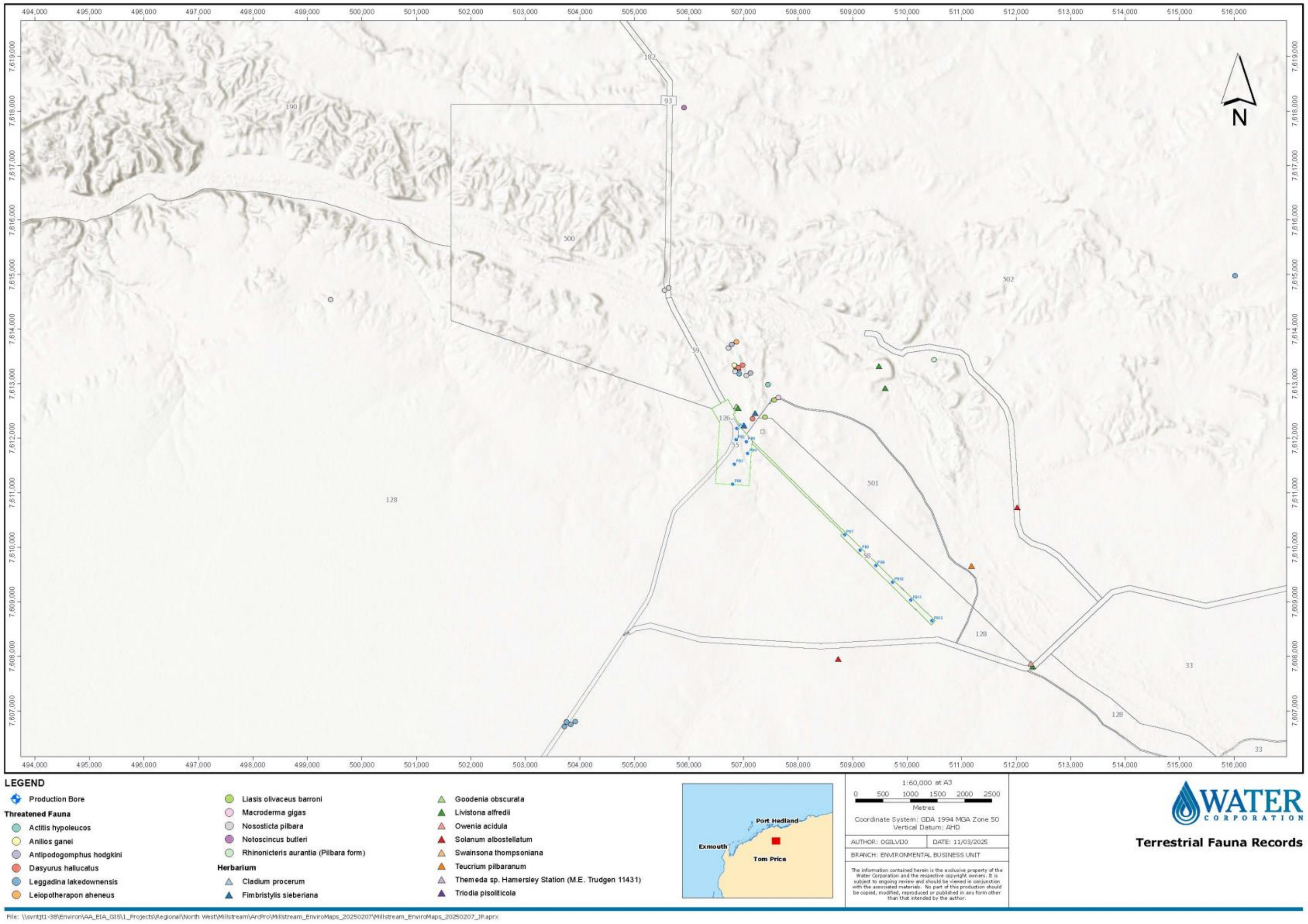


Figure 33: Terrestrial Fauna Records

8.4 Studies and Investigations

- Braimbridge, M, Antao, M and Loomes, R, 2010, Groundwater dependent ecosystems for Millstream: ecological values and issues, Environmental water report series, Report no. 13, Department of Water, Government of Western Australia, 2010).

8.5 Environmental Values

The pools, river and supporting vegetation of the Millstream Wetlands provide suitable habitat for:

- Pilbara olive python
- Gane's blind snake
- Fortescue grunter

The pools, river and supporting vegetation of the Millstream Wetlands provide suitable foraging habitat for conservation significant fauna.

8.6 Potential Environmental impacts

8.6.1 Direct

The proposal comprises the abstraction from existing production bores. No clearing of vegetation is required for this proposal and no direct impacts to terrestrial fauna and habitat are proposed.

8.6.2 Indirect

Terrestrial fauna may be indirectly impacted by potential impacts to habitat associated with the Millstream Wetlands, caused by groundwater abstraction altering the volume of the springflow from the aquifer entering Millstream pools and river.

Potential impacts to terrestrial fauna and habitat may include:

- Changes to the connectivity of pools may impact aquatic fauna habitat availability.
- Impacts to deep permanent pools as habitat for large bodied, long-lived fish species and water birds.
- Potential impacts to shallow macrophyte habitat inundated and available for macroinvertebrates, small-bodied fish and juveniles of large-bodied fish.
- Changes in salinity have the potential to impact fish and macroinvertebrates directly through physiological stress and indirectly through loss of macrophyte habitat.

Changes to the connectivity of pools may impact aquatic fauna habitat availability.

Maintenance of pool connectivity is important to ensure habitat availability and quality allow fauna movement and nutrient transfer for aquatic fauna. This includes the requirement for:

- Permanent connectivity between wetlands from Deep Reach pool to Livistona pool.
- Persistence of flow down from Livistona pool to Gregory Gorge.

Discharge from the Millstream aquifer (through the Deep Reach pool to Livistona pool reach) maintains river ecosystems downstream to Gregory Gorge between river flow events. When flow to Gregory Gorge ceases, the river contracts to a series of large pools with intermittent pools drying out as the duration of no flow extends. Changes in the flow regime and the impact on the duration of no flow periods has the potential to impact these pools.

Pool stage height data has been used to assess the connectivity between the pools where, the pool stage height in the most downstream pool (Livistona pool) is above the pool cease to flow (CTF), then outflow and inflow is assumed to be occurring, and upstream connectivity maintained. This assumption is valid given the record period flow from Deep Reach pool and stage height in Livistona pool are strongly correlated (R^2= 0.7781: 1996 - 2003) (Figure 34).

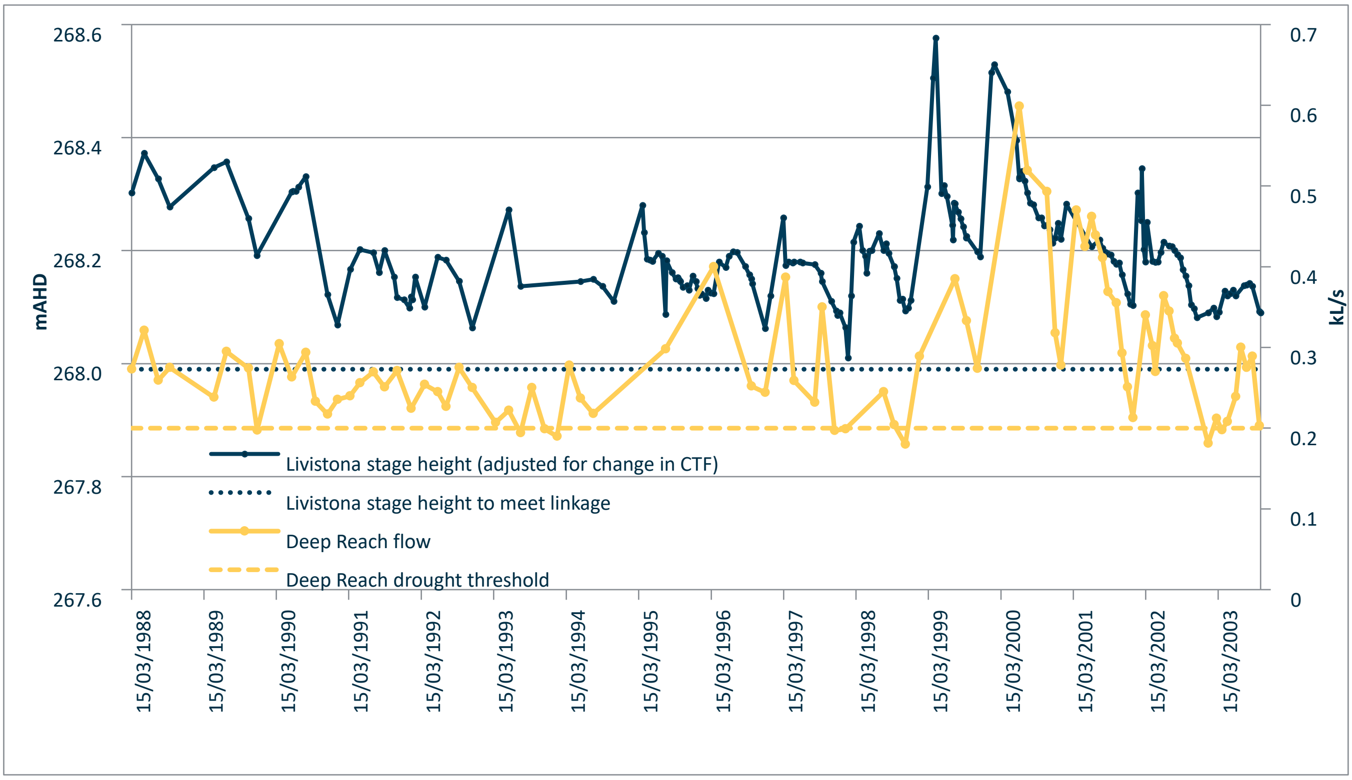


Figure 34: Record period flow from Deep Reach pool and stage height in Livistona pool

Analysis of available data from 1988 to 2003 for Livistona pool shows that connectivity between pools was maintained for the period of record (Figure 35). This is supported by anecdotal evidence that the Fortescue River from Deep Reach pool to Livistona pool is permanently connected. Livistona pool stage data remained above the CTF during the reporting period, indicating Deep Reach pool has been sufficient to maintain the connectivity of surface water downstream to Livistona pool.

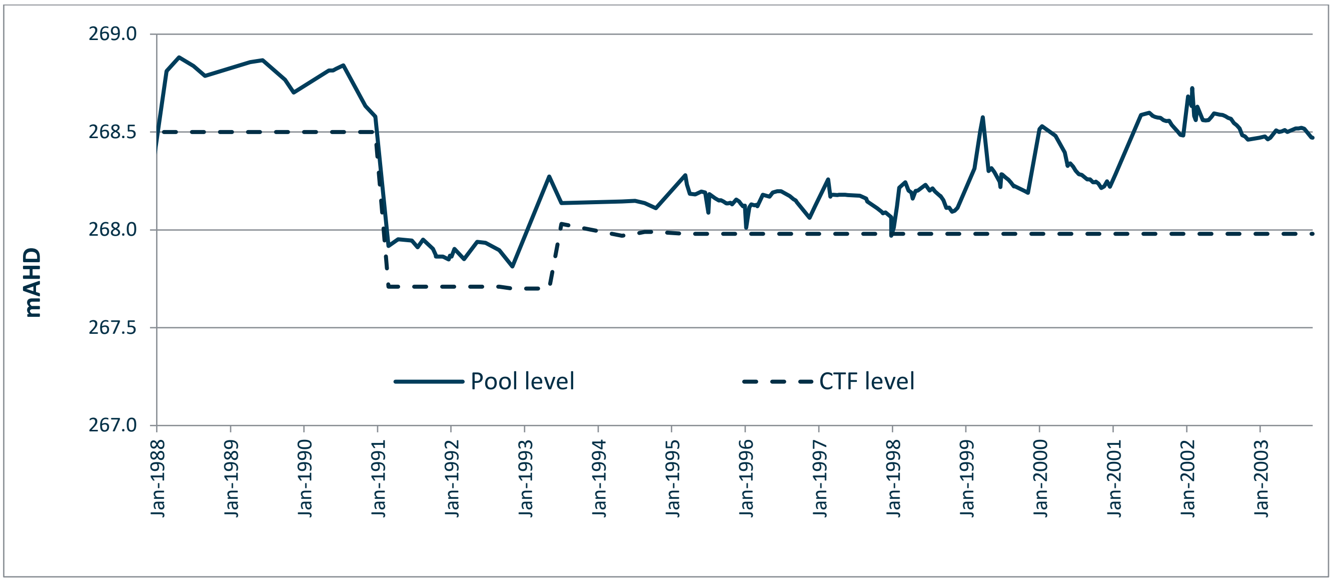


Figure 35: Livistona pool stage height and associated pool cease to flow.

There is no statistical relationship between Deep Reach spring discharge and the occurrence and duration of no flow at Gregory Gorge. This is presumably due to the distance between the two sites, inputs from the Millstream Delta and other factors influencing flow between Deep Reach pool and Gregory Gorge. Pool size when compared to Gregory Gorge flow rates indicates that permanent pools reduce in size as flow rates decline and intermittent pools will generally dry out when Gregory Gorge is receiving low or no flow (Figure 36).

Figure 37 shows the number of months, per year, of no flow in the Fortescue River at the Gregory George gauging station. Periods of no flow from Deep Reach and the occurrence and duration of no flow at Gregory Gorge is not statistically related. This indicates that the dominate source of flow through Gregory Gorge are rainfall-runoff events across the almost 14,000 km^2 Fortescue River catchment. The proposal is not expected to impact surface water flows to Gregory George, as the springflow from Deep Reach has not historically shown correlation with pool levels.

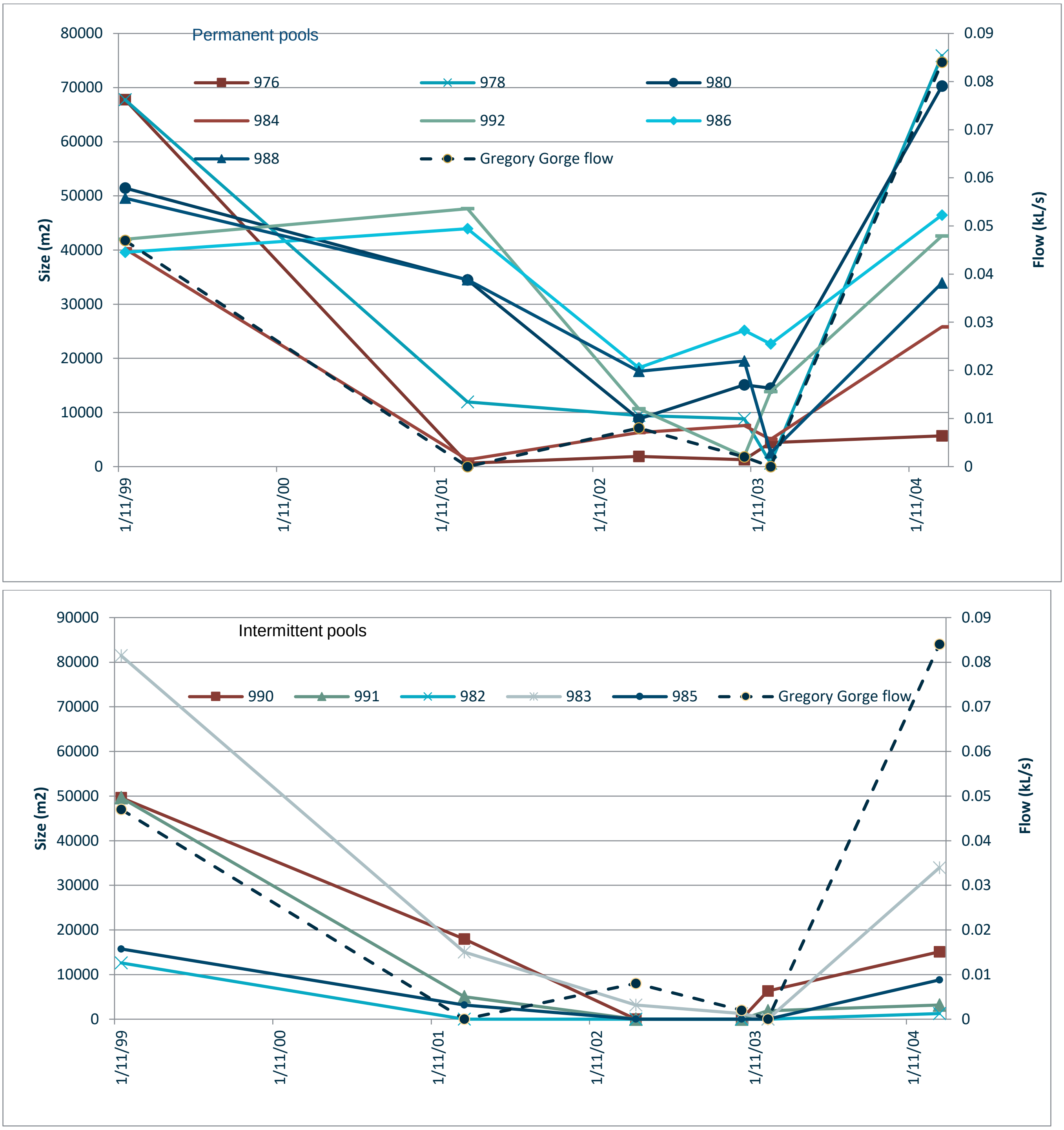


Figure 36: Pool size between Livistona and Gregory Gorge (top) Permanent pools and (bottom) semi-permanent/intermittent pools

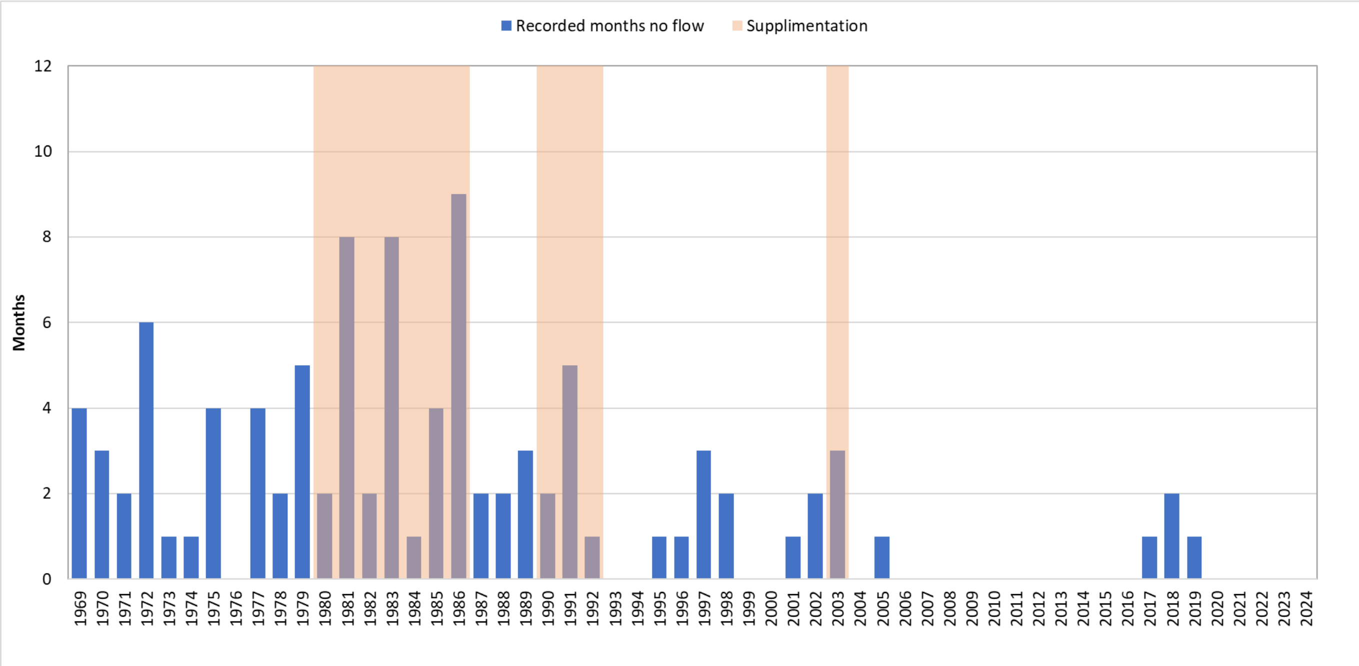


Figure 37: 708002 Fortescue River at Gregory Gorge recorded months of no flow

Impacts to deep permanent pools as habitat for large bodied, long-lived fish species and water birds.

Pool depth and stability are important drivers of fish community structure in Pilbara rivers with deep pools supporting greater species richness, abundance and diversity of fish (Beasley, 2006; Morgan et al., 2009). Van Dam (2005) found that in deep pools along the De Grey River there was a shift in size distribution to fewer large fish and relatively more small fish when depths dropped below 2.7m. As a way of comparing the two study areas we looked at the fish species identified at both De Grey River (Van Dam et al. 2005) and Millstream (Morgan, Gill et al. 2003; Beesley 2006). The two study areas were found to have the same species of large, bodied freshwater fish. As such DoW applied 2.7 m as the threshold for maintaining deep pool habitat.

Pool bathymetry (Ramsey and Gibbs, 2014) shows that Deep Reach, Crossing, Palm and Livistona pools all provide deep pool habitat. Pool water level monitoring for Livistona and Deep Reach pools indicate that deep pool habitat (depths >2.7m) (Table 21). Similarly continuous discharge from Crossing and Palm pools indicates that water levels have been maintained above the pool cease to flow level and deep pool habitat has also been maintained in these pools.

Table 21: Pool bathymetry data collection June 2014 (DWER, 2019 unpublished)

Pool	CTF (date)	Max depth	Max width	Max length
Deep Reach	291.64m AHD (07/1995)	14.1m	100m	2600m
Crossing	280.51m AHD (11/1995)	6.0m	95m	2000m
Palm	271.87m AHD (01/1996)	6.8m	100m	3000m
Livistona	267.99m AHD (04/1995)	5.7m	50m	600m
Chinderwarriner	292.97m AHD (1995)	7.8m	30m	260m

Potential impacts to shallow macrophyte habitat inundated and available for macroinvertebrates, small-bodied fish and juveniles of large-bodied fish.

Submerged macrophyte habitats have been shown to be important preferred habitats for some species of macroinvertebrates. Significant areas of macrophyte habitat occur along the channels that connect the pools and around the pools themselves. Ensuring these macrophytes are present and available as habitat will help to maintain macroinvertebrate and fish fauna diversity.

Macrophytes in the riverine pools were typically restricted to depths less than 1.5m. Macrophytes are therefore common in the relatively shallow channels and the downstream portions of pools (Dames and Moore, 1984). Pool or channel shape is a strong determinant of the amount of habitat available. Pools with steep banks (such as Deep Reach pool) have a narrow area of habitat available and the macropyhtes form a narrow discontinuous border. Macroinvertebrate data obtained from Millstream during the Pilbara Biological Survey (Pinder, Halse et al., 2010) indicate that while most species occurred at a minimum depth of 42cm and 90cm, an additional 41 species were not present at depths less than 1.5m (Figure 38). This suggests that potential impacts may be likely where pool depths are less than 1.5m.

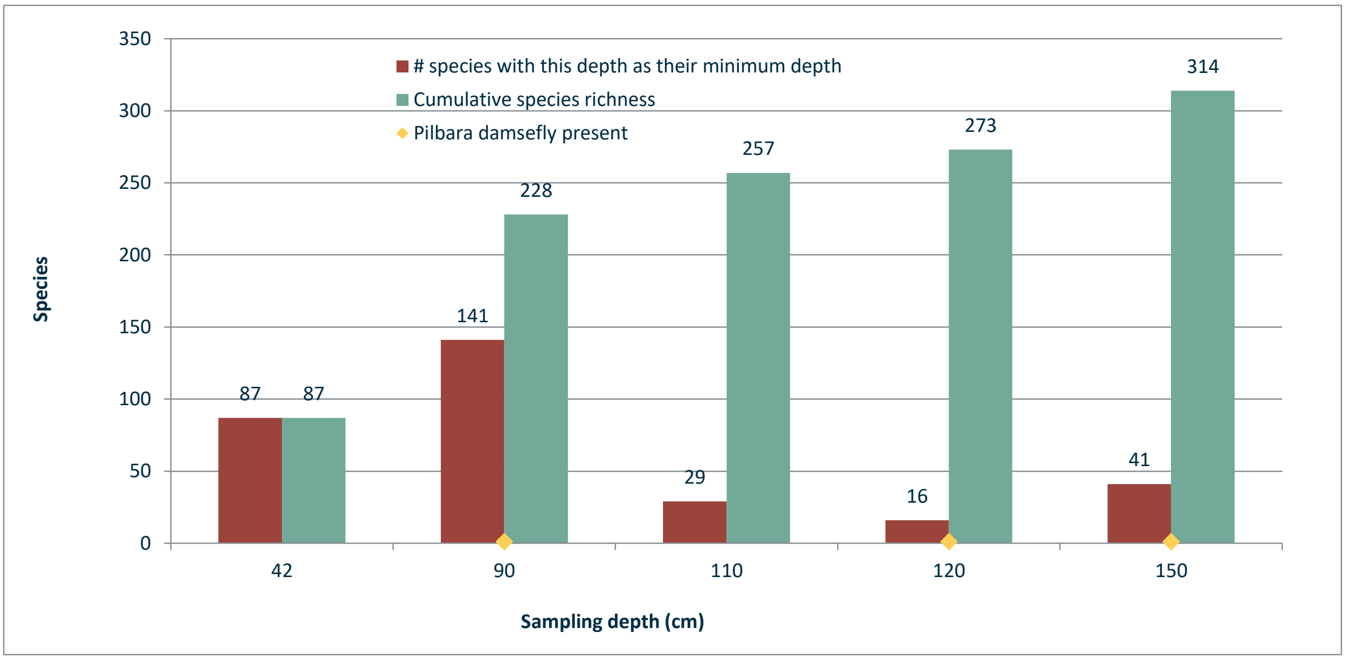


Figure 38: Species richness at sample depths (Pinder, Halse et al., 2010)

Water levels in Deep Reach, Crossing, Palm and Livistona pools have historically been maintained at or above their cease to flow point and all have areas of potential shallow pool habitat with depths less than 1.5m. Livistona pool stage data remained above the CTF during the reporting period, indicating outflow from Deep Reach and Chinderwarriner pools has been sufficient to maintain the connectivity of surface water downstream to Livistona pool.

Changes in salinity have the potential to impact fish and macroinvertebrates directly through physiological stress and indirectly through loss of macrophyte habitat.

Changes in salinity have the potential to impact fish and macroinvertebrates directly through physiological stress and indirectly through loss of macrophyte habitat. In determining the monitoring criteria for the Millstream system, the Millstream Environmental Water Requirements Study (DWER, 2019 unpublished excerpt) determined:

- Macrophytes appear to be the most susceptible (compared with fish and macroinvertebrates) to salinity changes with most species experiencing sublethal effects between 1000 mg/l – 2000 mg/L (converted from EC x 0.64) (Hart, Bailey et al., 1991; Bacher G and Garnham J, 1992).
- Macroinvertebrate sampling across the Pilbara suggest that most species can tolerate salinity levels up to 3000 mg/L with an observed decline in richness once salinity exceeded about 3300 mg/L (Pinder, Halse et al., 2010).
- Fish sampling along the Fortescue River (Beesley, 2006) concluded that fish species richness within pools was not related to measured conductivity levels up to 1531 mg/L. While Pilbara wide fish sampling showed that most species sampled in the Millstream pools tolerate salinity levels up to 2500 mg/L (Morgan, Gill et al., 2003).
- Based on data gathered from previous reports, the maximum recorded salinity in Deep Reach pool is 1400 mg/L. However, this level is below salinities known to impact on fish and macroinvertebrates. It is also below the salinities previously recorded in Palm pool when nine species of macrophyte where present (Beesley, 2006).

Based on this DWER set a 1400 mg/l TDS target at Deep Reach pool and 1086 mg/L at Chinderwarriner pool to maintain fauna health. Water quality of Deep Reach and Chinderwarriner pool indicates:

- TDS in the Deep Reach pool typically ranges between 220mg/l to just over 1400mg/L (Figure 39).
- Chinderwarriner pool salinity complied with Trigger of 1086 mg/L with the exception of one monitoring event (1,392mg/L in December 2015) (Figure 40).

Since the implementation of the 2014 WRMOS the target has been passed twice in January 2023 and January 2024. These higher values both precede significant drops in TDS and correspond with significant elevations in pool level. Analysis indicates these events correspond with flow events at Gregory Gorge. These peaks reflecting an initial flush of TDS from the upstream Fortescue River catchments and Millstream tributaries during the initiation of wet season flows. These levels are still well below salinities known to impact on fish and macroinvertebrates (DWER, 2019).

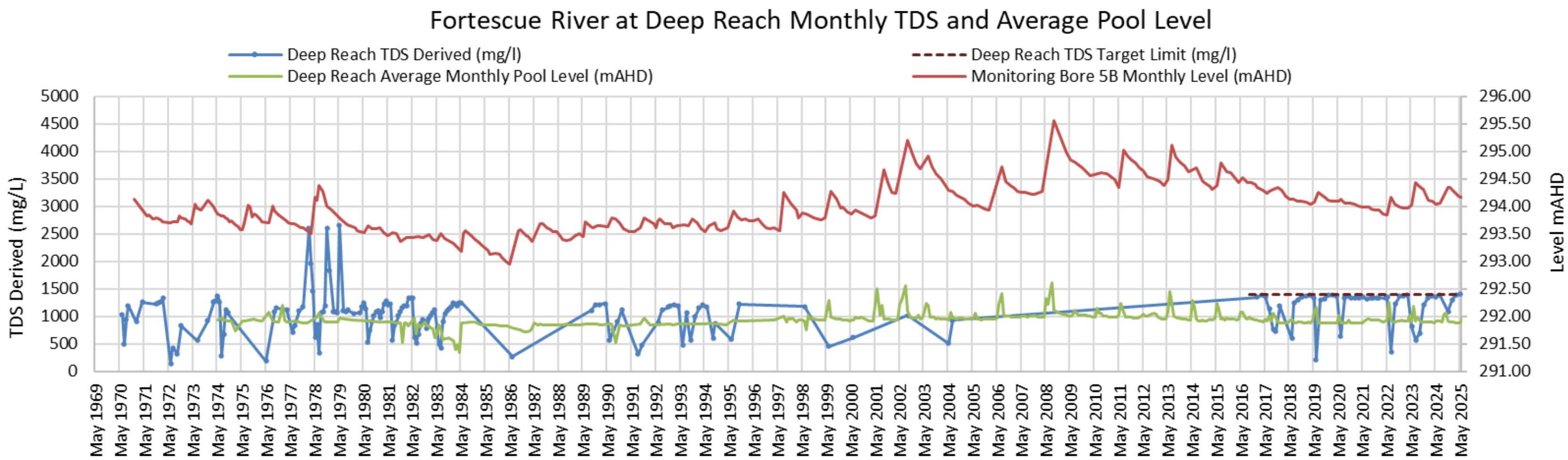


Figure 39: Fortescue River at Deep Reach pool observed TDS, TDS Target Limit, Pool Level and Groundwater Level at 5B

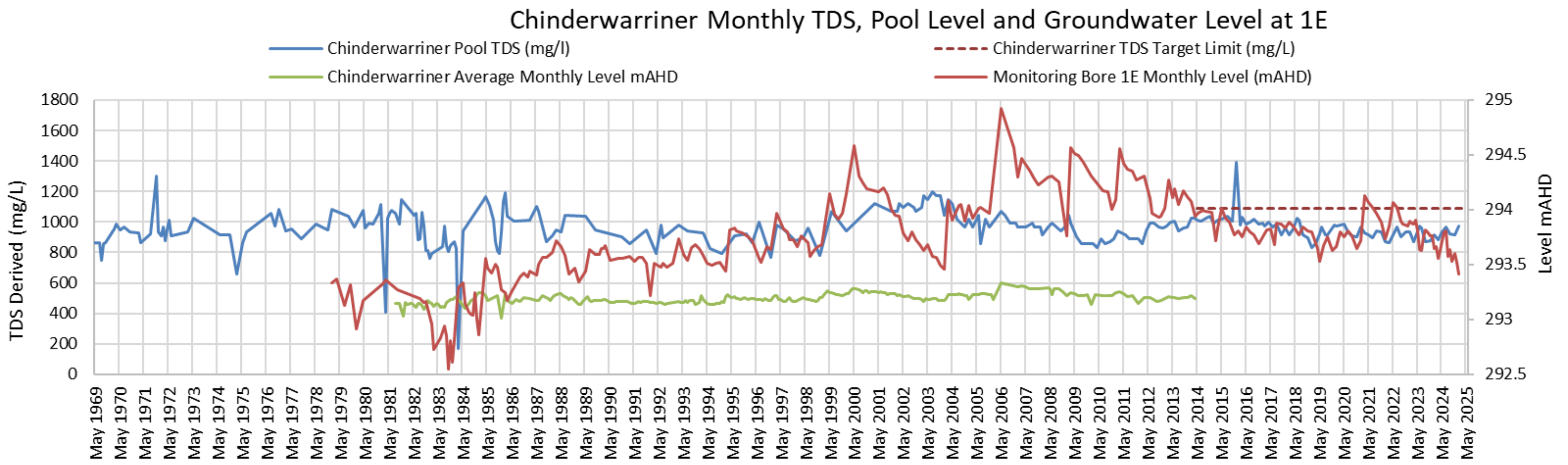


Figure 40: Chinderwarriner pool observed TDS, TDS Target Limit and Pool Level

8.7 Mitigation

The minimisation and management measures to minimise and mitigate impacts to riparian and GDVs from springflow into the Millstream Wetlands and pools are presented in the WRMOS (Appendix B). The adaptive management measures and response mitigation measures are outlined in the WRMOS are discussed in the Inland Waters chapter and presented in Appendix B.

8.8 Assessment and Significance

As discussed in the Inland Waters section, pool levels within the Millstream Wetlands are not solely directly related to groundwater abstraction with over 84% of water being fed by the Fortescue River. Groundwater abstraction from the proposal is not expected to impact the pool water levels and associated vegetation and fauna habitat within the Millstream Wetlands. Historical monitoring was shown that the Deep Reach water levels remained above the CTF during the reporting period, indicating connectivity has been maintained with downstream pools to Livistona pool. It has also been demonstrated that there is poor correlation between Deep Reach spring discharge and the occurrence and duration of no flow at Gregory Gorge, indicating any observed impacts at Gregory Gorge are not attributable to the proposal and likely to be caused by the decline in rainfall generated runoff as a consequence of tropical cyclones, and lows. Salinity concentrations have also generally remained within monitoring criteria outlined in the 2014 WRMOS.

8.9 Environmental Outcomes

It is not expected for groundwater abstraction to significantly impact pool water levels and associated wetlands and fauna habitat as water supply to the pools is predominately sourced during the wet season as a result of tropical cyclones and lows. As such no significant impacts to habitat and terrestrial fauna associated with the pools and wetlands are expected as a result of implementation of the proposal and it is expected that the EPA objective "*To protect terrestrial fauna so that biological diversity and ecological integrity are maintained*" can be met.

9. Subterranean Fauna

9.1 EPA Environmental Factor and Objective

The objective of the EPA (2016) Environmental Factor Guideline for Subterranean Fauna is:

To protect subterranean fauna so that biological diversity and ecological integrity are maintained.

9.2 Relevant Policy and guidance

- Statement of environmental principles, factors, objectives and aims of EIA (EPA, 2023).
- Environmental Factor Guideline - Subterranean Fauna (EPA, 2016)
- Technical Guidance - Subterranean fauna surveys for environmental impact assessment (EPA, 2021)
- The sampling program pre-dates the requirements outlined in the Technical Guidance - Subterranean fauna surveys for environmental impact assessment published in 2021.

9.3 Receiving Environment

The Millstream aquifer system occupies a broad palaeovalley between the Hamersley and Chichester ranges. The Millstream aquifer comprises the Millstream dolomite which abuts and exchanges water with the Fortescue alluvial aquifers and aquifers in the Proterozoic rocks (Figure 42). The Millstream aquifer is formed from a succession of Cainozoic alluvial, colluvial and lacustrine sediments of which calcrete (dolomite), with well-developed solution cavities, is the major aquifer (Barnett and Commander, 1985). The aquifer is of varying thickness with a maximum depth of 50 m and a varying saturated thickness of up to 33 m (Haig 2009). It has an area of 950 km^2 and is largely unconfined except for a portion to the east that is overlain by the Kangiangi Clay (Figure 43). Borefield is located within the Millstream dolomite (Figure 41). The Millstream dolomite is a middle to late tertiary calcrete and calcareous dolomite with layers of silcrete, clay and gravel. The dolomite is up to 46 m thick and is typically vuggy with cavities of up to 0.5 m high: it is cavernous in some places with sinkhole development at the surface (DoW, 2009).

Aquifers in the Pilbara region have been associated with diverse subterranean fauna. Bicarbonate-rich aquifers such as Millstream exhibit an abundant and diverse assemblage of stygofauna with richness proportional to sampling effort (Reeves et al., 2007). The richness of species recorded from the Millstream aquifer is 16 species, of which five species are cyclopid copepods of the genus *Diacyclops* (Eberhard et al., 2005).

The Millstream aquifer is a continuous hydrostratigraphic unit without any intrusions (Figure 42 to Figure 44) and there are no distinct pockets of habitat within the aquifer (Haig, 2009). The stygofauna habitat within the Millstream aquifer is therefore connected. Any lowering of the watertable within the aquifer will not lead to separation of habitat or loss of connectivity.

The historical MAL ranges from 293.02 mAHD in 1984 (minimum) to 295.14 mAHD in 2006 (maximum), which is a 2.2m watertable change since operation of the borefield in 1969 (Figure 45).

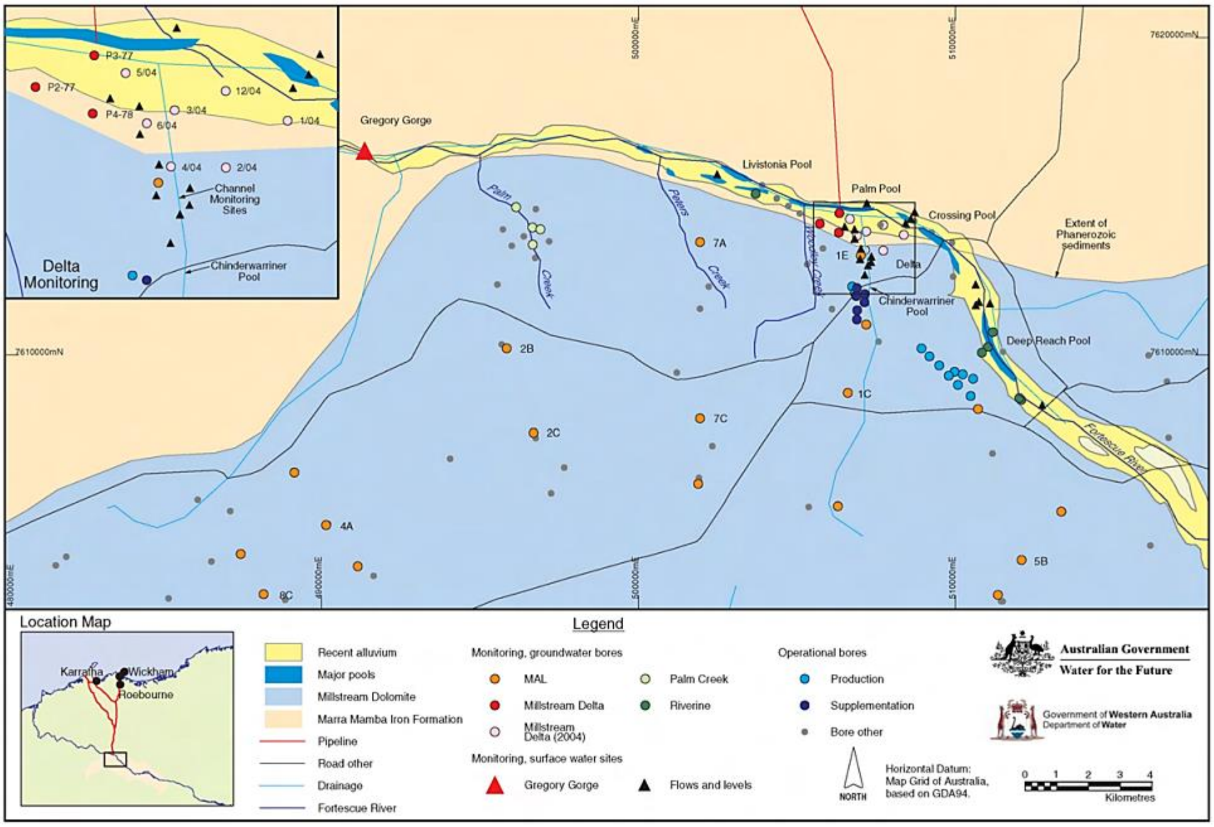


Figure 41: Millstream Borefield and Monitoring Assets

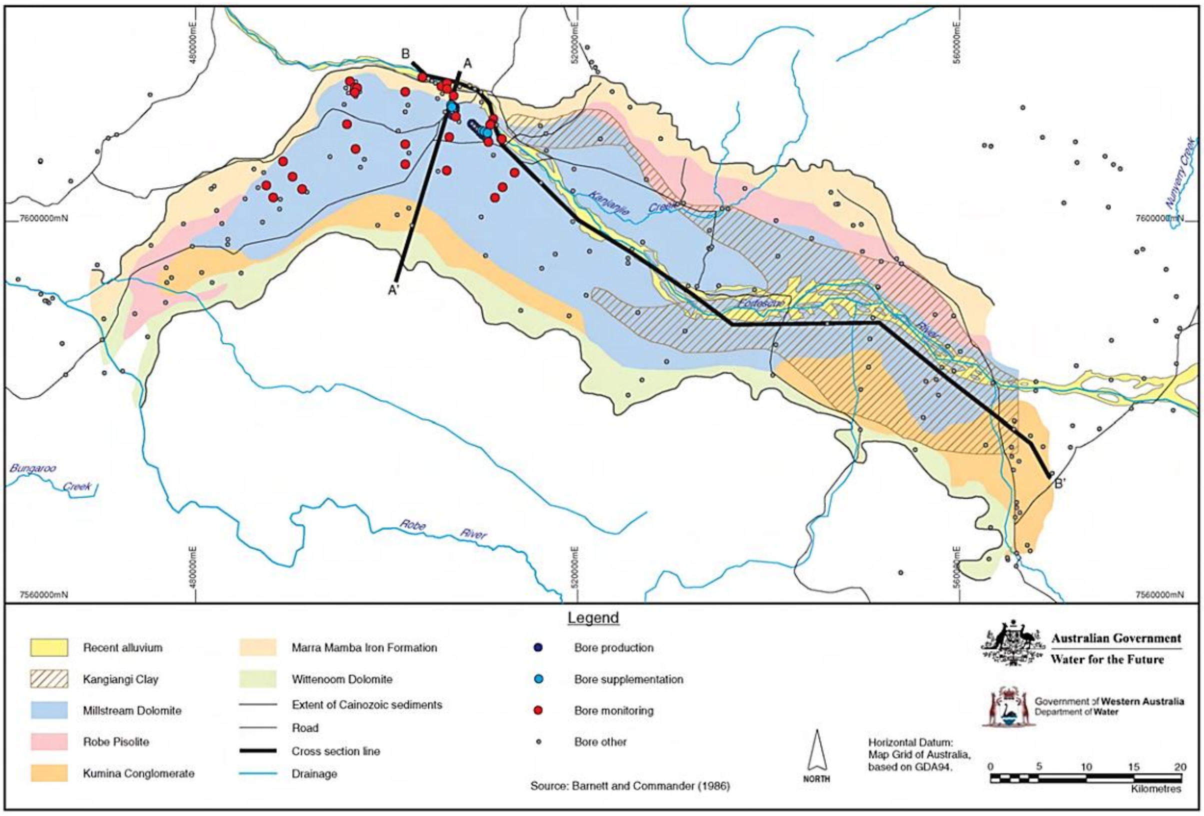


Figure 42: Geology of the Millstream dolomite aquifer (DoW, 2009)

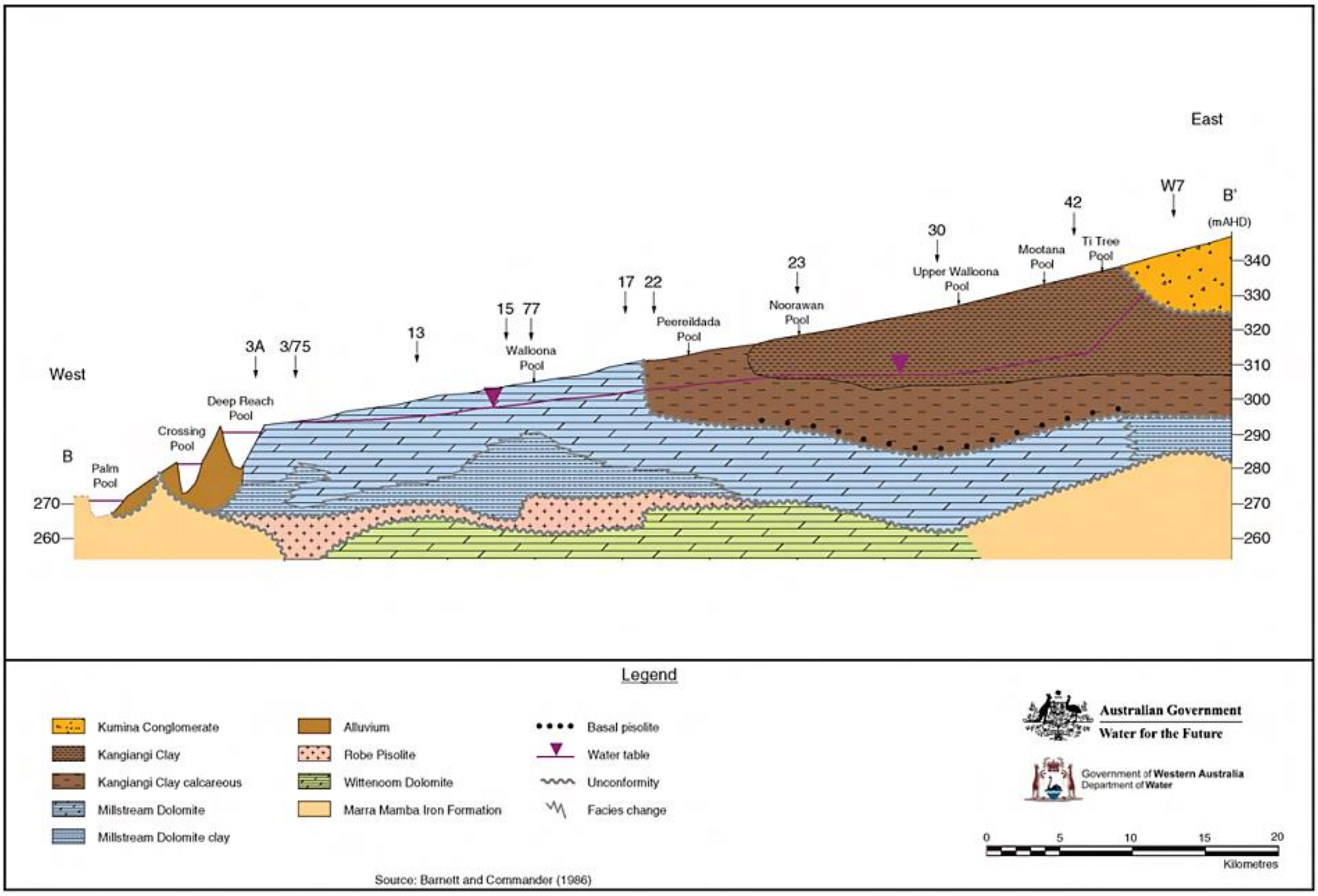


Figure 43: Geological cross-section B of the Millstream aquifer system along Drainage (DoW, 2009)

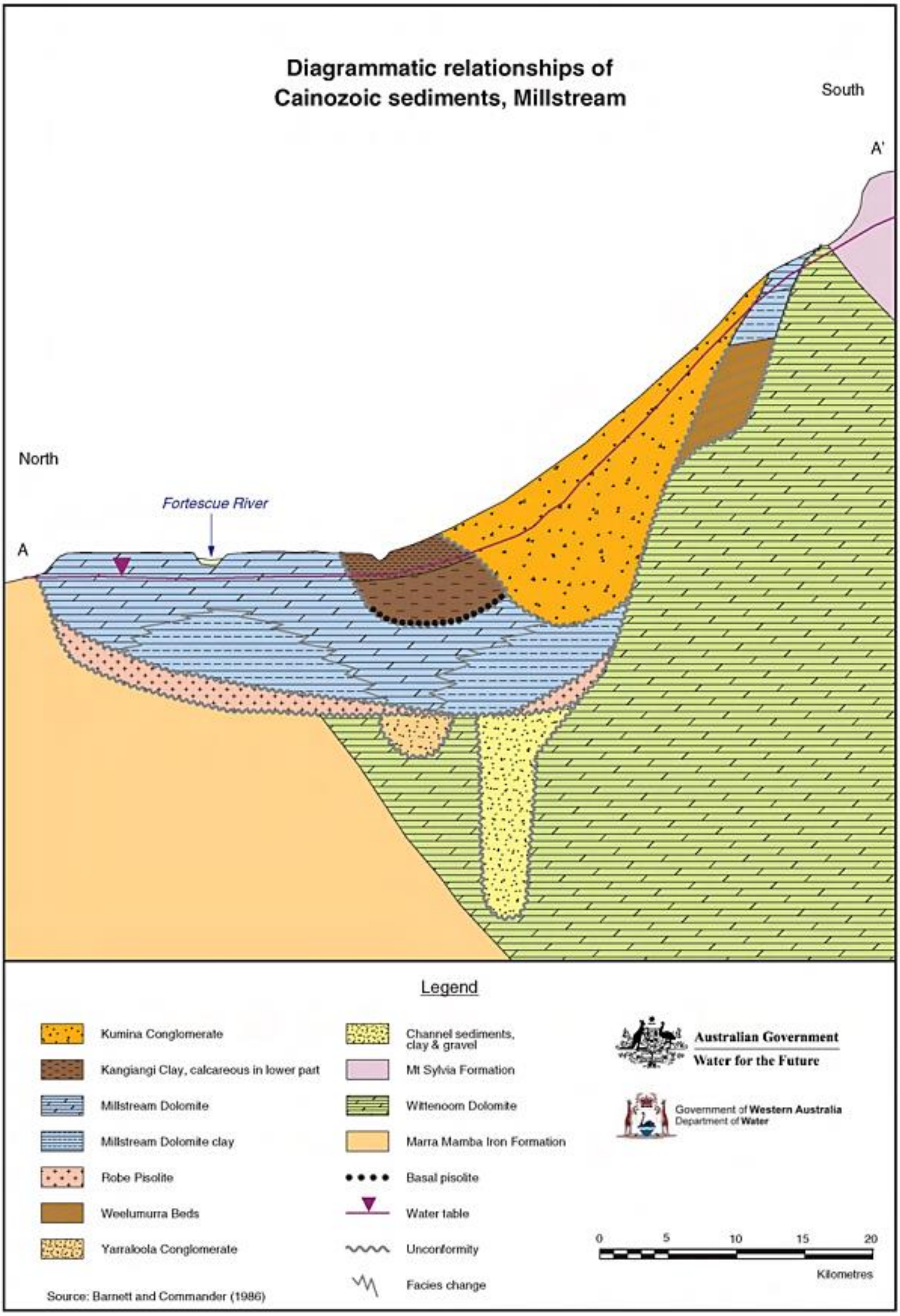


Figure 44: Millstream aquifer geologic cross-section A, across drainage (DoW, 2009)

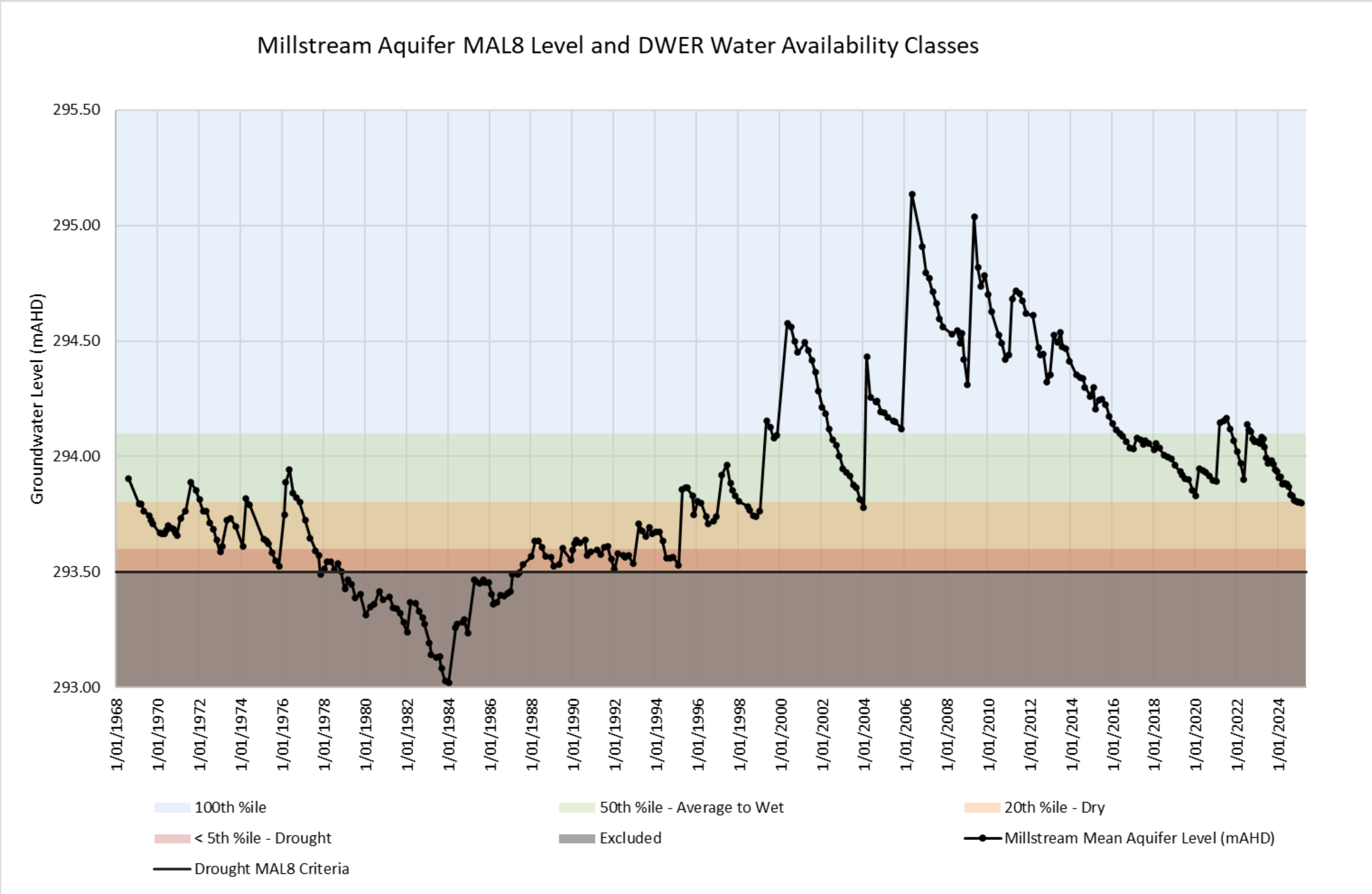


Figure 45: Historical MAL8

9.4 Studies and Investigations

A comprehensive subterranean fauna sampling program has been previously undertaken and reported in:

- Reeves, JM, De Deckker, P & Halse, SA 2007, 'Groundwater ostracods from the arid Pilbara region of northwestern Australia: distribution and water chemistry', Hydrobiologia, 585, 99-118.
- Eberhard, SM, Halse, SA & Humphreys, WF 2005, 'Stygofauna in the Pilbara region, north-west Western Australia: a review', Journal of the Royal Society of Western Australia, 88, 167-176.

9.5 Environmental Values

The Millstream aquifer provides habitat for stygofauna. The Millstream aquifer comprises one habitat type, being the Millstream dolomite, which is an extensive stratigraphic unit throughout the Pilbara. The Millstream dolomite contains well-developed solution cavities and is continuous hydrostratigraphic unit without any intrusions. The range of habitat is 950 km^2, with a maximum saturated thickness of 33 m.

The habitat is known to support 16 stygofauna species, of which five species are cyclopid copepods of the genus *Diacyclops* (Eberhard et al., 2005). The Millstream aquifer provides an extensive range and thickness for these stygofauna species and provides connectivity for these species to migrate within the aquifer.

9.6 Potential Environmental Impacts

Subterranean fauna habitat may be directly impacted by a reduction in habitat as a result of the groundwater abstraction from the Millstream aquifer.

During the early to mid-1980's the MAL fell dramatically in response to abstraction at levels above 9.5GL/a for a 7-year period (peaking at just below 16GL in 1983) this was exacerbated by extremely low riverflow and recharge and a 3-year hydrological drought. As a consequence, in 1984 the MAL reached a minimum observed level of 293.02 mAHD. This drawdown of the watertable, was assessed by DoW in 2009 to be 0.23 m below the average natural MAL around Millstream and representing a storage depletion of approximately 23GL (DoW, 2009). The watertable recovered in May 1984 to 293.27 mAHD.

In 2006 following record recharge the MAL reached a peak of 295.14 mAHD.

Since the commencement of operations in 1969 the maximum range in level change is 2.2 m which was limited to a period of 6 months during 1984. With a saturated thickness of up to 33m, this range represents a maximum observed change in available habitat of 6.7%. The proposal is not expected to reduce the watertable to levels observed in 1984.

The proposal may result in a reduction in subterranean fauna habitat due to groundwater abstraction. The volume of abstraction is significantly less than the volume of abstraction in 1984, as such the loss of subterranean fauna is not expected to significantly reduce the available habitat and will be limited to 5%. As previous monitoring results have shown, the water table recovered, and therefore reinstating the availability of stygofauna habitat. The extent of stygofauna habitat of 950 km^2 is not expected to change as a result of the proposal. The saturated thickness of the stygofauna habitat is not expected to reduce to less 30m as a result of the proposal. The extent and availability of stygofauna habitat is considered suitable to support the presence and diversity of stygofauna within the Millstream dolomite fauna habitat and no significant impacts to the presence and diversity of stygofauna species are expected as a result of implementation of the proposal.

Groundwater abstraction has not resulted in a change to the lateral availability of subterranean fauna habitat. The extent of habitat is consistent with no distinct pockets of specialist or localised habitat and the habitat is connected.

Groundwater abstraction is not expected to result in a significant impact to stygofauna due to the availability of remaining habitat present.

9.7 Mitigation

Mitigation management measures for the protection of saturated stygofauna habitat are presented in the WRMOS (Appendix B) The relationship between ecosystems and their water sources for the Millstream Wetland system is complex. This is due to the highly variable and unpredictable climate and the large number of habitats maintained by the Millstream aquifer. To develop ecological water requirements and management criteria for this system, DWER focused on the key hydrological processes and relationships that need to be maintained. Aquifer ecosystems were defined as “Ecosystems that have direct access to the Millstream aquifer, including minor springs, stygofauna and groundwater-dependent vegetation present across the aquifer”.

For the aquifer ecosystems DWER determined they could be monitored via the MAL of eight bores across the aquifer (MAL8) (Figure 4). The department also identified key hydrological relationships (hydro-ecological linkages) and the associated management criteria required to maintain. To maintain healthy stygofauna communities, which are dependent on the aquifer: Mean aquifer level needs to remain within the range of natural variability to enable to provide habitat for stygofauna.

The department based the ecological water requirements on data collected during those periods when the hydro-ecological linkages, were being met. The department also characterised the ecological water requirements into three water availability classes, based on the percentage of time they occurred in the past, to account for the Pilbara’s highly variable climate. For each water availability class, the department has used the ecological water requirements to set management criteria for the MAL that should not be breached (Table 22). Management criteria (flow and MAL) were set in the 2013 Pilbara groundwater allocation plan using data available to 2009.

Table 22: Aquifer groundwater level criteria to support aquifer ecosystems

Mean aquifer level triggers and criteria (based on mean aquifer level calculated as the average across the MAL8 bores)			
Recharge class	**Target[1] (mAHD)**	**Trigger[2] (mAHD)**	**Criteria[3] (mAHD)**
3 (average to wet)	>294.00		293.80
2 (dry)		293.70	293.60
1 (drought)		293.57	293.50

Target[1] Set at a mean aquifer level that should be met (or exceeded) at the beginning of the water year to confirm recharge class 3 (average or above average conditions). Once met, it is acceptable for the mean aquifer level to drop below the target.

Trigger[2] Set to initiate management actions once breached. It is anticipated that the triggers allow 6–12 months’ warning of a criteria breach depending on abstraction rates.

Criteria[3] Set as the aquifer level that should not be breached.

In 2014, to protect the stygofauna, DoW specified a Drought MAL8 criteria of 293.5 mAHD as a condition of the Corporation’s licence to abstract. This criterion represents the maximum allowed reduction of habitat, as a condition of the Corporation’s licence to abstract. It equates to a less than 5% allowable reduction in habitat. In February 2025 the observed MAL was at 293.797 mAHD and has been maintained above 293.5 since levels recovered in 1988.

9.8 Assessment and Significance of Residual Impact

Since the commencement of operations in 1969 the maximum observed reduction of the available habitat for subterranean fauna is 2.2m (6.7% change) which was limited to a period of 6 months during 1984. A 2.2m change represents a change from the maximum stygofauna habitat thickness of 33m to 30.8m. This change to watertable represents a maximum observed change in available stygofauna habitat of 6.7%, which is not considered a significant impact due to 30.8m stygofauna habitat thickness available. This reduction in stygofauna habitat observed in 1984 is not expected to occur as a result of implementation of the proposal given the proposal comprise lower abstraction volumes.

Implementation of the proposal may result in a 5% change to subterranean fauna habitat. Since 2014 a maximum allowed reduction of habitat was set by DWER as a condition of the Corporation's licence to abstract, the criteria represent a less than 5% allowable reduction in habitat. A 5% change in watertable is not considered a significant impact given there is extensive fauna habitat remaining; 950 km^2 range extent and around 30m of saturated thickness remaining. This is not considered a significant impact to subterranean fauna, due to the maximum allowable change representing less than 5% of the available habitat and the ability for subterranean fauna to migrate to lower in the aquifer. The proposal is not likely to have a significant impact on subterranean fauna due to the availability of substantial suitable habitat remaining.

9.9 Environmental Outcomes

Implementation of the proposal is not expected to result in significant impact to stygofauna as the maximum allowable reduction in habitat is limited to 5%, with abundant remaining habitat available for stygofauna.

Implementation of the proposal is not expected to significantly impact subterranean fauna and it is expected that the EPA objective "*To protect subterranean fauna so that biological diversity and ecological integrity are maintained"* can be met.

10. Holistic Impact Assessment

The Millstream Wetlands are a series of rivers, pools and wetlands and listed in the Directory of Important Wetlands (Environment Australia, 2001). The Millstream Wetlands include permanent and semi-permanent riverine pools and flowing streams, including:

- Pools along the Fortescue River including Deep Reach, Crossing, Palm and Livistona pools.
- Off-channel pools and wetlands including Chinderwarriner pool, the Millstream Delta, Woodley Creek, Peters Creek and Palm Creek.

The pools are of cultural significance to the Yindjibarndi Aboriginal people, are associated with the riparian communities of springs and Pools Pilbara (P2) PEC and 12 groundwater dependent vegetation communities, are habitat for terrestrial fauna, and are located within the Millstream Chichester National Park being a tourist destination in WA.

The proposal has the potential to indirectly impact the Millstream Wetlands by altering the volume of the springflow from the aquifer entering Millstream Wetlands pools and rivers. The lowering of the watertable also has the potential to impact stygofauna through habitat loss.

Potential impacts to pool and river levels within the Millstream Wetlands are not solely directly related to groundwater abstraction as a result of implementation of the proposal with any observed impacts most likely to be caused by dry climatic conditions and a period without a significant recharge event from a tropical cyclone. The pool water levels in Millstream aquifer are directly correlated to the Fortescue River flows with springflow from the Millstream aquifer being approximately16.3% of water source into the pools.

Previous abstraction volumes and monitoring data has shown groundwater abstraction volumes greater than 9GL/a (up to 16GL/a) showed impact at year 3 at Deep Reach and after year 1 at Chinderwarriner pools. These impacts are not expected given the proposal is for a lower ongoing abstraction volume and a temporary contingency period. All pool water levels recovered. No long-term significant impacts to pool water levels are expected as a result of implementation of the proposal.

Potential impact and observations on pool levels, vegetation and erosion within the Millstream Wetlands are primarily due to climatic conditions and not directly related to groundwater abstraction as a result of implementation of the proposal. Groundwater abstraction from the proposal is not expected to impact the pool and river levels within the Millstream Wetlands with any observed impacts likely to be caused by climatic conditions which are not attributable to the proposal.

The maximum allowable reduction in stygofauna habitat, which represents a less than 5% reduction, is not considered significant given the extent of remaining suitable habitat remaining.

No clearing is proposed and no direct impacts to the Millstream Wetlands are expected as a result of implementation of the proposal.

The proposal is not expected to result in significant impacts to the Millstream Wetlands and implementation of the proposal is expected to meet the EPA objectives.

11. Cumulative Impact Assessment

The Millstream aquifer is fully allocated with no further groundwater available for general licensing. The Corporation is the major licensee for the Millstream aquifer, with a total allocation of 9GL/a for public water supply purposes. The five other groundwater licences registered for Millstream aquifer have a combined allocation of 0.573 GL/a (refer to Table 23). As other groundwater users are 6.37% of total allocation, abstraction from the Millstream Borefield is the key consideration in assessing cumulative impacts on groundwater and groundwater dependent values, while taking into consideration external pressures (such as climate change) and the dependence of potable water supply on the existing borefield.

While implementation of the proposal has the potential to contribute to cumulative impacts through direct groundwater abstraction and indirect impacts to groundwater dependant values, previous monitoring has shown prolonged periods of groundwater abstraction over 9.5GL/a did not result in significant long-term impacts. Given the proposal is for temporary abstraction no greater than 9GL/a, this is considered more minor in magnitude and potential impacts are not to a level that would alter the likely environmental outcomes for groundwater and dependant values.

In considering the impact of climate change for the near future (2030), prior to the estimated delivery of a new source:

- Higher temperatures including hotter and more frequent days and increased potential evapotranspiration are projected. The annually averaged warming across all emission scenarios is projected to be around 0.6 to 1.5 °C above the climate of 1986–2005.
- Rainfall variability will continue to be strong due to the continued influence of the El Nino Southern Oscillation in the near future (CSIRO, 2025; DWER, 2024). Natural variability is projected to dominate over any trends due to greenhouse gas emissions. Changes to rainfall are possible, but the direction of change cannot be confidently projected. Increases, decreases or unchanged wet season rainfall are all equally plausible (CSIRO, 2025; DWER, 2024). Little change to dry season rainfall is projected.
- Projections indicate with high confidence a future increase in the intensity of extreme rainfall events, although the magnitude of the increases cannot be confidently projected (CSIRO, 2025).

In accordance with DWER's guide to future climate projections for water management in Western Australia (2024):

- The Corporation undertakes demand and supply planning considering for both wetter and drier rainfall futures utilising the storylines approach (Water Corporation, 2024).
- Utilise 5km^2 downscaled projections from the Bureau of Meteorology's (BoM) National Hydrological Projections (until the next generation of climate projections are available) (Wilson, 2022; BoM, 2025).

In addition, the Corporation follows these internal principals:

- Prepare for a climate that will not be the same as the past by exploring links between climate drivers and system responses.
- Use the best data available about changes in the climate. Understand the influence of uncertainty.
- Informed decision making - understand and manage climate risk in all parts of the system.
- Protect value for customers by assessing multiple, equally plausible, climate futures (this includes using Representative Concentration Pathway (RCP) 4.5 as a baseline emissions scenario but also considering futures under a high emissions scenario RCP8.5).

For Harding Dam and Millstream aquifer:

- Eight sets of downscaled projections broken into three scenarios are used to assess ongoing near and medium-term risks to the supply systems.
- Two of the most extreme dry scenarios and two unprecedented dry scenarios (replicated from historical data sets), equitable to 10th and 40th percentile rainfall, are used to assess the immediate short-term risk to Millstream aquifers triggers and criteria in order to inform the TWG's immediate adaptive management decisions.

The Corporation considers the RiWI Act licencing process provides a comprehensive framework for accessing cumulative impacts. RiWI Act licensing decisions relating to the Millstream aquifer are guided by the Pilbara Groundwater Allocation Plan (2013), which considers cumulative impacts. Specifically, page 34 of the Plan (2013) acknowledges the importance of considering cumulative impacts of hydrological changes on water resources and dependent ecosystems as part of individual assessment of proposals. In addition, the assessment of cumulative impacts is an inherent part of the RiWI Act licensing framework as it is a water allocation regime and sustainable water management is the primary goal. Any RiWI Act assessment of sustainability will take into account the impacts from other threatening processes and activities, such as climate change on recharge.

Table 23: Third party groundwater licences from the Millstream aquifer

Licenced Party	Licence	Allocation KL	Allocation GL	Aquifer	Issue Date	Expiry Date	Status	Licenced address
Water Corporation	105696	6000000	6	Hamersley - Millstream	17/03/22	11/05/24	Application for renewal submitted April 2024	Lot 128 Fortescue Millstream Wellfield; Crown Reserve 36991; Lot 128 Fortescue (Bores 6, 12, Millstream Borefield); Crown Reserve 36991, Lot 55 Millstream (Bores PB1, PB2, PB3, PB4, PB5, PB6 Millstream Borefield)
Water Corporation	205069	3000000	3	Hamersley - Millstream	17/03/22	21/02/27		Crown Reserve 36991; Crown Reserve 36991
Pilbara Iron Company (Services) Pty Ltd	156125	300000	0.3	Hamersley - Millstream	2/10/24	1/10/34		L47/47 West Angelas Railroad, L47/47
Pilbara Iron Company (Services) Pty Ltd	177274	220000	0.22	Hamersley - Millstream	2/10/24	1/10/34		L47/48; GENERAL LEASE I195323; GENERAL LEASE H954583; L47/67; GENERAL LEASE I195323; GENERAL LEASE N104716; GENERAL LEASE I195323; GENERAL LEASE I195323; GENERAL LEASE I195323; L47/127; GENERAL LEASE I195323; GENERAL LEASE I195323; L7SA; GENERAL LEASE I195323; GENERAL LEASE I195323; GENERAL LEASE I195323; GENERAL LEASE I195323; L47/81; GENERAL LEASE N104716; L47/80; GENERAL LEASE I195323; GENERAL LEASE I195323; GENERAL LEASE I195323;

Licenced Party	Licence	Allocation KL	Allocation GL	Aquifer	Issue Date	Expiry Date	Status	Licenced address
								L47/79; L47/49; GENERAL LEASE I195323; L47/128; GENERAL LEASE N104716; GENERAL LEASE I195323; GENERAL LEASE I195323; L47/47; GENERAL LEASE I195323
Shire of Ashburton	179791	31500	0.0315	Hamersley - Millstream	23/08/17	22/08/27		Roebourne Wittenoom Road Reserve
Fortescue Ltd	181138	20000	0.02	Hamersley - Millstream	8/10/18	7/10/28		E47/1342; E47/1578
API Management Pty Limited	204173	1500	0.0015	Hamersley - Millstream	31/03/20	30/03/30		E47/1171I

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Appendix A: Proposal Content Document

Proposal Content Document

Table 1: General proposal content description

Proposal title	Abstraction of Groundwater from the Millstream Aquifer
Proponent name	Water Corporation
Referrer name	Water Corporation
Short description	Water Corporation proposes to continue abstracting groundwater from the Millstream aquifer to supply West Pilbara Water Supply Scheme (WPWSS). The proposal is to continue groundwater abstraction from the Millstream aquifer up to 6GL/a until 2032 with a contingency of up to 3GL/a until 2027. The proposal allows for groundwater abstraction from Millstream Borefield as a secondary water source for the WPWSS.

Table 2: Proposal content elements

Proposal element	Location / description	Maximum extent, capacity or range
Physical elements		
Millstream Borefield	Figure 2 of the Supporting Document	Production Bores PB1, PB2, PB3, PB4, PB5, PB6 - Crown Reserve 36991, Lot 55 Millstream Production Bores (unequipped) PB7, PB8, PB9, PB10, PB11, PB12 - Crown Reserve 36991, Lot 58 Millstream
Construction elements		
Not applicable – groundwater abstraction is currently occurring with established assets		
Operational elements		
Groundwater abstraction from the Millstream aquifer	Figure 2 of the Supporting Document	Continue groundwater abstraction up to 6GL/a until 2032 with an additional contingency up to 3GL/a to 2027
Rehabilitation		
Not applicable – assets are in operation		
Commissioning		

Not applicable – assets are in operation		
Decommissioning		
The need and timing of the decommissioning of groundwater bores and associated infrastructure will be as confirmed as and when the long-term operation of the Millstream aquifer as a source for the WPWSS is defined.		
Other elements which affect extent of effects on the environment		
Proposal time*	Maximum project life	Abstraction up to 6GL/a until 2032, and up to 3GL/a contingency to 2027
	Construction phase	Not applicable
	Operations phase	See maximum project life
	Decommissioning phase	Not defined

** Proponents should only provide realistic timeframes to avoid unnecessary change to proposal applications at referral (section 38C), assessment (section 43A) or post assessment (section 45C).*

Appendix B: Water Resource Management Operation Strategy 2014

Infrastructure Planning Branch

West Pilbara
Water Resource Management Operation Strategy

August 2014

watercorporation.com.au

WATER CORPORATION

Addendum to a water resource operating strategy associated with a water licence issued by the Department of Water and Environmental Regulation

This addendum applies to:

- The Water Resource Management Strategy that has been approved and signed by the Department of Water and Environmental Regulation for the following Groundwater and Surface Water licences and associated scheme on the 25th August 2014 and subsequent addendum that was approved on the 15th September 2016.

Licence Number	Water Corporation Scheme
SWL 105715	West Pilbara-Harding Dam
GWL 105696	West Pilbara-Millstream

This addendum takes effect from 1st May 2020, until the expiry date for the water licences identified in the list above.

Intent

The intent of this addendum is to amend Table 10, 11, 12 and 15 of the Water Resource Management Operation Strategy as detailed below.

Table 10 Recharge class - water availability based on wet season flow

Recharge class	Water availability condition	Total wet season flows (Dec–April) ML
1	Drought	< 43,000 for previous 3 or more years
2	Dry	< 43,000 for previous 1 or 2 years
3	Average to wet	> 43,000 (if MAL is < 294.00 mAHD at the beginning of the water year, recharge class 2 should be applied).

Table 11 Criteria for pool outflows to maintain Millstream wetlands

Recharge Class	Deep Reach flow triggers and criteria measured below Crossing Pool (Location 3*) with corresponding groundwater levels as measured in Bore 5B					
	Target		**Trigger**		**Criteria**	
	Flow kL/s	**Bore 5B mAHD**	**Flow kL/s**	**Bore 5B mAHD**	**Flow kL/s**	**Bore 5B mAHD**
3	0.26	294.14	0.23	293.98	0.21	293.78
2			0.23	293.98	0.21	293.78
1			0.21	293.78	0.18	293.60
	Chinderwarriner flow triggers and criteria with corresponding groundwater levels as measured in Bore 1E					
	Target		**Trigger**		**Criteria**	
	Flow kL/s	**Bore 1E mAHD**	**Flow kL/s**	**Bore 1E mAHD**	**Flow kL/s**	**Bore 1E mAHD**
3	0.27	293.84	0.23	293.58	0.20	293.49
2			0.23	293.58	0.20	293.49
1			0.20	293.49	0.16	293.41

* Location 3 coordinates – GDA94: Zone:50 E:508915.3 N:7614020.4

Table 12 Targets for water distribution, water quality and vegetation condition across Millstream wetlands

Applicable target	**Measure**	**Recharge Class 1** **5th %ile** **Drought criteria**	**Recharge Class 2** **20th ile** **Dry Criteria**	**Recharge Class 3** **50th ile** **Average/wet Criteria**
Allowable period of no flow at Gregory Gorge	flow	period of no flow not > than 4 month	period of no flow not > than 3 months	period of no flow ≤ 1 month
Other springs (Woodley, Palm and Peters)	flow	Flow in Palm	Flow in Palm and Peters	Flow in Palm, Peters and Woodley
Livistona	flow	TBD		
Deep Reach water quality	TDS	1,400mg/L		
Chinderwarriner pool water quality	TDS	1,086mg/L		
Millstream remote sensing	NDVI	Observable loss in canopy PFC (measured as a loss in PFC of 5 or more)		
Millstream in-situ vegetation condition assessment	Canopy condition	Statistically significant change in Canopy condition score or other observed response to water stress		

Table 15 Responses when criteria are breached for Millstream aquifer

Response (see note)	**Wetlands (see Table 11)** Recharge class 3 and 2 Trigger	**Wetlands (see Table 11)** Recharge class 3 and 2 Criteria	**Wetlands (see Table 11)** Recharge class 1 Trigger	**Wetlands (see Table 11)** Recharge class 1 Criteria	**Aquifer riparian vegetation, other springs and stygofauna (see Table 13)** Recharge class 3 Criteria	**Aquifer riparian vegetation, other springs and stygofauna (see Table 13)** Recharge class 2 Criteria	**Aquifer riparian vegetation, other springs and stygofauna (see Table 13)** Recharge class 1 Trigger	**Aquifer riparian vegetation, other springs and stygofauna (see Table 13)** Recharge class 1 Criteria
Level 1. Monitoring and reporting								
• Increase frequency of GW and flow monitoring to fortnightly as soon as practicable*	√	√	√	√	√	√	√	√
• Increase reporting to DWER and TWG on monitoring results and implementation of Level 1 and 2 responses to monthly	√	√	√	√	√	√	√	√
• Undertake remote sensing monitoring and budget for end of dry season in-situ vegetation monitoring	√	√	√	√		√	√	√
• Increase downstream flow monitoring	√	√	√	√		√	√	√
Level 2. Supplementation Plan								
• Trigger supplementation plan	√	√	√	√				
Level 3. Scheme response								
• Commence negotiations with Rio Tinto to take additional water from Bungaroo and consider other contingencies.		√		√		√	√	√
Level 4. Critical response								
• Supplementation to proceed with consideration of targets set in Table 12 and in discussion with TWG.		√		√**				
• Use contingency sources				√		√		√**
• Reduce take				√				√**

Note: if recharge class 2 or 3 criteria are breached subsequent recharge class 1 or 2 responses are to be implemented.

* Any change to baseline monitoring will occur after consultation with TWG and in consideration of the cost-benefit of additional monitoring.

** This response can be triggered earlier if monitoring against targets (table 12) indicates that ecosystems are responding to reduced water availability.

Government of **Western Australia**
Department of **Water and Environmental Regulation**

Amending the addendum to the water resource operating strategy

The licensee may apply to amend this addendum at any time, to account for exceptional circumstances*

* Licensee must continue to abide by the existing condition/commitment until any change is approved by the Department of Water.

Agreement

The Water Corporation acknowledge that compliance with the approved addendum to the Water Resource Management Operating Strategy is a condition of holding a licence, as issued under Section 5C of the Rights in Water and Irrigation Act 1914, to take and use water and hereby agree to implement the commitment(s) within this addendum.

Signature	**Signature**
Approved by KEN WALKER	**Approved by** GARY HUMPHREYS
(Authorised officer, Water Corporation)	(Authorised officer, Department of Water and Environmental Regulation)
Date 12/6/2020	**Date** 15/6/2020

Government of **Western Australia**
Department of **Water and Environmental Regulation**

Addendum to water resource management operation strategy associated with a water licence issued by the Department of Water and Environmental Regulation (DWER)

This addendum applies to:

- The Water Resources Management Operation Strategy that has been approved and signed by the Department of Water and Environmental Regulation for the following Groundwater Licences and associated scheme on the 25th of August 2014.

Licence Number	Water Corporation Scheme
SWL 105715	West Pilbara Harding
GWL 105696	West Pilbara Millstream

The addendum takes effect from **1 November 2018,** until the expiry date of the water licence for the scheme identified in the list above.

Intent

The intent of the addendum is to adjust the following commitments in the Water Resource Management Operation Strategy associated with the above water licences.

2.3 Reporting

The Water Corporation will submit the following for this scheme:

Amend reporting statement

2. A Water Monitoring Review is due to the DWER by 31st October 2021 as per the DWER's Guidelines for Water Corporation Reporting and Licensing and every five years thereafter.

4. Operating Rules

Remove operating rule

15. Any water meter changes that have occurred during the water year must be detailed in the Water Monitoring Summary / annual report. Current water meter details for each production bore are detailed in Appendix B.

9. Commitments

Update and add commitments to table

No	Commitment	Timeline
2	Submit to DWER through the online portal a Water Monitoring Summary / annual report as per DWER's *Guidelines for Water Corporation Reporting and Licensing.*	31st July
3	Submit to DWER through the online portal a Water Monitoring Review as per DWER's *Guidelines for Water Corporation Reporting and Licensing.*	31st October 2021 and every 5 years thereafter
14	Notify DWER of any water meter installation including a replacement, as per the *Rights in Water and Irrigation Amendment Regulations 2018.*	Within 30 days of installation
28	Total volume abstracted during the water year for the licence/s is to be submitted to DWER annually via the Water Monitoring Summary.	31st July

Amending the Addendum

The licensee may apply to amend this addendum at any time.

Agreement

The Water Corporation acknowledge that compliance with the approved addendum to the Water Resource Management Operation Strategy is a condition of holding a licence, as issued under Section 5C of the Rights in Water and Irrigation Act 1914, to take and use water, and hereby agree to implement the commitments within this addendum

Signature	**Signature** M Viskovich ....
Approved By KEN WALKER	**Approved By** Matt Viskovich ....
(Authorised Officer, Water Corporation)	(Authorised Officer, Department of Water and Environmental Regulation)
Date 10 / 10 / 18	**Date** 22 / 10 / 18

Government of **Western Australia**
Department of **Water**

Addendum to water resource operating strategy associated with a water licence issued by the Department of Water

This addendum applies to:

- The Water Resources Management Operation Strategy (WRMOS) that was approved and signed by the Department of Water on 25 August 2014 for the following Groundwater Licences and associated scheme.

Licence Number	Water Corporation Scheme
GWL105696(6)	West Pilbara (Millstream borefield)
SWL105715(6)	West Pilbara (Harding Dam)

The addendum takes effect from **13th September 2016** until the expiry date of the WRMOS for the scheme identified in the list above.

Intent

The intent of this addendum is to amend Table 8, Table 11, Section 6.2.4 and the title of Table 14 of the WRMOS as detailed below.

5.3 Millstream Borefield Monitoring Requirements

5.3.1 Millstream Aquifer

Table 8 Millstream Aquifer Monitoring Program

Frequency	Requirement #3
Every month *or annually in November if the bore is not in operation since the start of the water year*	• Production bore water rest levels, abstraction and conductivity #1 #2 (as TDS mg/L and all samples tested in the lab) Millstream Production bores (equipped) – PB1, PB2, PB3, PB4, PB5, PB6
Every month	• Water rest levels bores PB7, PB8
Before use	• Deep Reach and Chinderwarriner Supplementation bore conductivity (TDS mg/L and all samples tested in the lab) and report to DoW Deep Reach supplementation bores – DR1(1/84), DR2(2/84), DR3(3/84) • Chinderwarriner supplementation bores – CP1(1A), CP2(8/81), CP3(11/81)
Every month when in use	• Deep Reach and Chinderwarriner Supplementation bore water rest levels, bore abstraction and conductivity (TDS mg/L and all samples tested in the lab) Deep Reach supplementation bores – DR1(1/84), DR2(2/84), DR3(3/84) Chinderwarriner supplementation bores – CP1(1A), CP2(8/81), CP3(11/81)
Every 2 months *or frequency to increase to*	• Water rest levels in monitoring bores MAL8 bores – 1C, 1E, 2B, 2C, 4A, 5B, 7C, 8C

monthly when MAL below 293.8 m AHD	• Water rest levels in monitoring bore 7A, PB7, PB8
Annually	• All production bores (equipped) water quality major components [#4] • Conductivity – PB7, PB8
Annually *When not in use*	• Deep Reach and Chinderwarriner Supplementation bore water rest levels and bore abstraction.

Notes

#1 DoW have set a performance indicator to maintain water quality, as an average across equipped bores, below 900 mg/L TDS.

#2 Temperature measurement is required if a conductivity at 25°C measurement is not taken.

#3 Any new or replacement production bore will be subjected to the same monitoring requirements as existing production bores.

#4 Results of all major component analysis to be presented in Water Monitoring Review.

#5 Every effort will be made to ensure monitoring occurs in the nominated month. Should there be an unforeseen event preventing readings being taken, the Water Corporation will resume monitoring as soon as practical.

Table 11 Criteria for Pool outflows to maintain Millstream wetlands

Applicable criteria	**Recharge Class**			
	1 5th %ile Drought criteria	**1 15th %ile Drought Trigger**	**2 20th %ile Dry Criteria**	**3 50th %ile Average/wet**
Wetlands				
Crossing Pool discharge	≥0.12kL/s	≥0.14kL/s	≥0.14kL/s	≥0.18kL/s
Chinderwarriner Pool discharge	≥0.11kL/s	≥0.14kL/s	≥0.16kL/s	≥0.21kL/s

6.2.4 Riverine and delta groundwater level criteria

Riverine and delta vegetation is supported by local groundwater levels which are largely recharged by pool outflows. However because local groundwater levels can also be influenced by several other factors, local groundwater level criteria have been set (in addition to pool outflow rates) to ensure groundwater levels are maintained and riverine and delta vegetation is supported (Table 14). These criteria levels are still being aligned to correspond with vegetation condition and will be considered as observation levels until a closer relationship is determined, with any action to be determined at the data reporting meeting in consultation with TWG. These levels will be reviewed at the next annual review report. These triggers and criteria are fixed and do not vary with recharge classes.

Table 14 Groundwater observation levels

Amending the Addendum

The licensee may apply to amend this addendum at any time.

Agreement

The Water Corporation acknowledge that compliance with the approved addendum to the Water Resource Management Operating Strategy is a condition of holding a licence, as issued under Section 5C of the Rights in Water and Irrigation Act 1914, to take and use water, and hereby agree to implement the commitments within this addendum.

Approved By KEN WALKER	**Approved By** GARY HUMPHREYS
(Authorised Officer Water Corporation)	(Authorised Officer, Department of Water)
Date 13 / 9 / 16	**Date** 15 / 9 / 2016
Signature	**Signature**

Infrastructure Planning Branch
Planning and Capability Group
Water Corporation

West Pilbara
Water Resource Management Operation Strategy

This Water Resource Management Operation Strategy describes specific operational details required to be followed as a condition of the water allocation licence.

REPORT PREPARED FOR:

	Approved	Date
Manager Water Source Policy and Compliance		7.8.14
Scheme Operator: Regional Business Manager, North West Region		11/08/2014
Process Manager: Branch Manager, Infrastructure Planning		12/8/14
Regulator: Department of Water		25/8/14

PROJECT TEAM:

Author - Stacey Rudd, Water Source Compliance Analyst
Graphics - Grecian Dempster, Spatial Analyst
Review – Jessica Smith, Danielle Higgs, Steve Thomas, Andrew Jones (Water Corporation), Michelle Antao (DoW)

August 2014

Copy No. Issue No.

Corporation File No. JT1 2014 00599 V01

IPB Report No. A4-2361

DOCUMENT MANAGEMENT

West Pilbara
Water Resource Management Operation Strategy
Corporation File No. ***JT1 2014 00599 V01***
Corporate Document No. ***365211***
IPB Report Number ***A4-2361***

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ACRONYMS / DEFINITIONS

DoW	Department of Water
DPaW	Department of Parks and Wildlife, formerly the Department of Environment
environs	Surrounding area / environment
EWR	Environmental water requirement
GL	Gigaliltres = 1 billion litres
kL	kilolitres = 1,000 litres
MAL	Mean aquifer level
MAL8	Bores used to obtain a mean aquifer level
ML	Megalitres = 1 million litres
supernatant	Waste stream from water treatment plant
Production bore	Bore used for the abstraction of groundwater for provision to scheme water customers
Supplementation bore	If groundwater levels reach a trigger level, supplementation bores will be used to supplement spring flows
WC	Water Corporation
WRMOS	Water Resource Management Operating Strategy

1. INTRODUCTION

The Department of Water (DoW) has issued the Water Corporation a licence to take groundwater under section 5C of the *Rights in Water Irrigation Act, 1914*, (RiWI Act) for the West Pilbara Water Supply Scheme. This Water Resource Management Operation Strategy (WRMOS) describes specific operation, monitoring and reporting requirements to be followed as a condition of the water allocation licence.

This version of the WRMOS has been updated from the previously approved version dated April 2008.

1.1 Scheme Categorisation

Corporation schemes are categorised into three types (basic, intermediate & advanced) based on the volume of water entitlement and environmental and socio-economic risk. This sets the tone for the scheme's licensing requirements, and the minimum content required in the WRMOS and compliance reports.

The DoW's *Guidelines for Water Corporation Reporting* March 2011 (the reporting guidelines) provides the rationale behind scheme categorisation, and the minimum reporting requirements for each scheme category.

For the West Pilbara Water Supply Scheme the current licensed entitlement is 15,000,000 kilolitres (kL)/year as a combined maximum for the Millstream Borefield and Harding Dam, which categorises the scheme as an advanced scheme. No amendment of this categorisation is considered necessary.

1.2 Scheme Description

Water for the West Pilbara Water Supply Scheme is currently sourced from Harding Dam and the Millstream Borefield. The two sources operate in conjunction with Harding Dam being used as the preferential source when quality allows. Water is sourced from the Millstream Borefield when use of Harding Dam is constrained. Refer to Figure 1 for a locality plan.

A new groundwater source has been established at Bungaroo Creek to meet Rio Tinto's water demand. Abstraction is licensed to Rio Tinto Iron Ore for an allocation of 10 gigalitres (GL)/year. Rio Tinto has constructed a new water pipeline to link the Bungaroo Creek borefield to the Corporation's existing water supply system. The Corporation has an agreement with Rio Tinto to accept and transfer around 8 GL/year of Bungaroo water source into the system to meet Rio Tinto's short term (~ 5 years) demand of 7.5 GL/year (note 0.5 GL/year assumed in water losses).

Dependant on arrangements with Rio Tinto, the borefield could potentially be utilised as a contingency source option for the Corporation. However it is unlikely this will be required in the medium term (2020+) because the estimated demand for the West Pilbara scheme will be only 7 GL/year when Bungaroo comes on line to service Rio Tinto's water demand.

1.2.1 Harding Dam

Harding Dam is located on the Harding River about 30 km south of Roebourne. Its reservoir has a storage capacity of 63.8 GL. Water is drawn from the reservoir and passes through a microfiltration water treatment plant before entering the scheme's distribution system. Water treatment is required to achieve compliance with drinking water quality guidelines.

Since commissioning of the plant in 2004, Harding Dam reservoir has provided the bulk of the scheme supply. A near continuous flow of supernatant water is released from the water treatment plant (approximately 5% of water production) downstream of the Dam. The supernatant is the by-product of microfiltration water treatment.

On occasions when Harding Dam is offline, scheme supply has been provided by Millstream Borefield. There is potential for environs downstream of the dam to be affected by dam operations. Figure 2 shows the location of the Harding Dam and the downstream environmental monitoring sites.

1.2.2 Millstream Borefield

The Millstream Borefield is located near the old Millstream Homestead, adjacent to the Fortescue River, about 130 km south of Roebourne. The borefield consists of 12 production bores that draw water from an unconfined aquifer within the Millstream Dolomite formation. Production bores 9 to 12 are currently unequipped. These four bores were unequipped due to salinity issues. Water is pumped from the borefield, chlorinated, then transferred to two 9 Megalitre (ML) summit tanks from where it gravitates into the distribution systems.

The Millstream area, most of which is within the Millstream Chichester National Park, is of major environmental, social and cultural importance. The natural pool and surrounding riverine ecosystems at Millstream rely on supply from the Fortescue River and the Millstream aquifer.

The borefield includes two sets of supplementation bores, which are available to supplement nearby Deep Reach and Chinderwarriner Pools during extended non-recharge periods. Water is pumped from the supplementation bores into the pools when outflow rates from Chinderwarriner and Crossing Pools fall below the environmental water provision trigger. Additionally the mean aquifer level (MAL) is another critical monitoring factor that influences the operation of the borefield. There are 8 monitoring bores across the Millstream area, which are used to determine the MAL and these are known as the MAL8 (1C, 1E, 2B, 2C, 4A, 5B, 7C and 8C).

The locations of abstraction bores, environmentally sensitive areas and associated monitoring networks are shown in Figure 3. Details of production bores are listed in bore information sheets in Appendix A.

1.3 Scheme Allocation

The West Pilbara Water Supply Scheme is operated under two licences issued under Section 5C of the RIWI Act. Surface Water licence 105715 has been issued for Harding Dam and expires on the 11 May 2024. Groundwater licence 105696 has been issued for the Millstream borefield and expires on the 11 May 2024. The licences allow a combined draw from these two sources up to a maximum of 15,000,000 kL/year. This is subject to meeting the conditions of this operating strategy.

The previous licences issued on the 5 December 2011 allowed a combined maximum draw of 16,000,000 kL/year. This short term increase was requested from the Water Corporation on the 20 May 2011 to meet demand due to the growth in the number of services in West Pilbara and approximately 6,000 new services pending approval to be connected. During this time there was increasing pressure from the Government to continue to connect new services in the West Pilbara area to support the Pilbara Cities vision. This was only a short term increase until the Bungaroo source was operational.

The scheme is designed to operate with Harding Dam as the preferential source with Millstream to be used when there are water availability or water quality problems associated with Harding Dam.

Harding and Millstream can be operated concurrently under the following conditions:

- The combined draw will not exceed 15 GL/year
- The draw from Millstream during periods of concurrent use is not to exceed 2 GL/year
- The aquifer water level and pool outflow criteria are still met
- All monitoring is undertaken as specified in the operating strategy
  The justification for the concurrent use is provided to the DoW within seven days.

Table 1 details the source and entitlement for the West Pilbara scheme. A licence amendment must be applied for if the forecast annual abstraction is likely to exceed the annual water entitlement.

Table 1 Source and entitlement details

Water Resource	Licence Number	Entitlement (kL/year)*
Hamersley - Fortescue (Millstream borefield)	GWL105696	15,000,000
Upper Harding (Harding Dam)	SWL105715	15,000,000

Note: *Annual combined draw (including any supplementation) is not to exceed 15,000,000 kL.

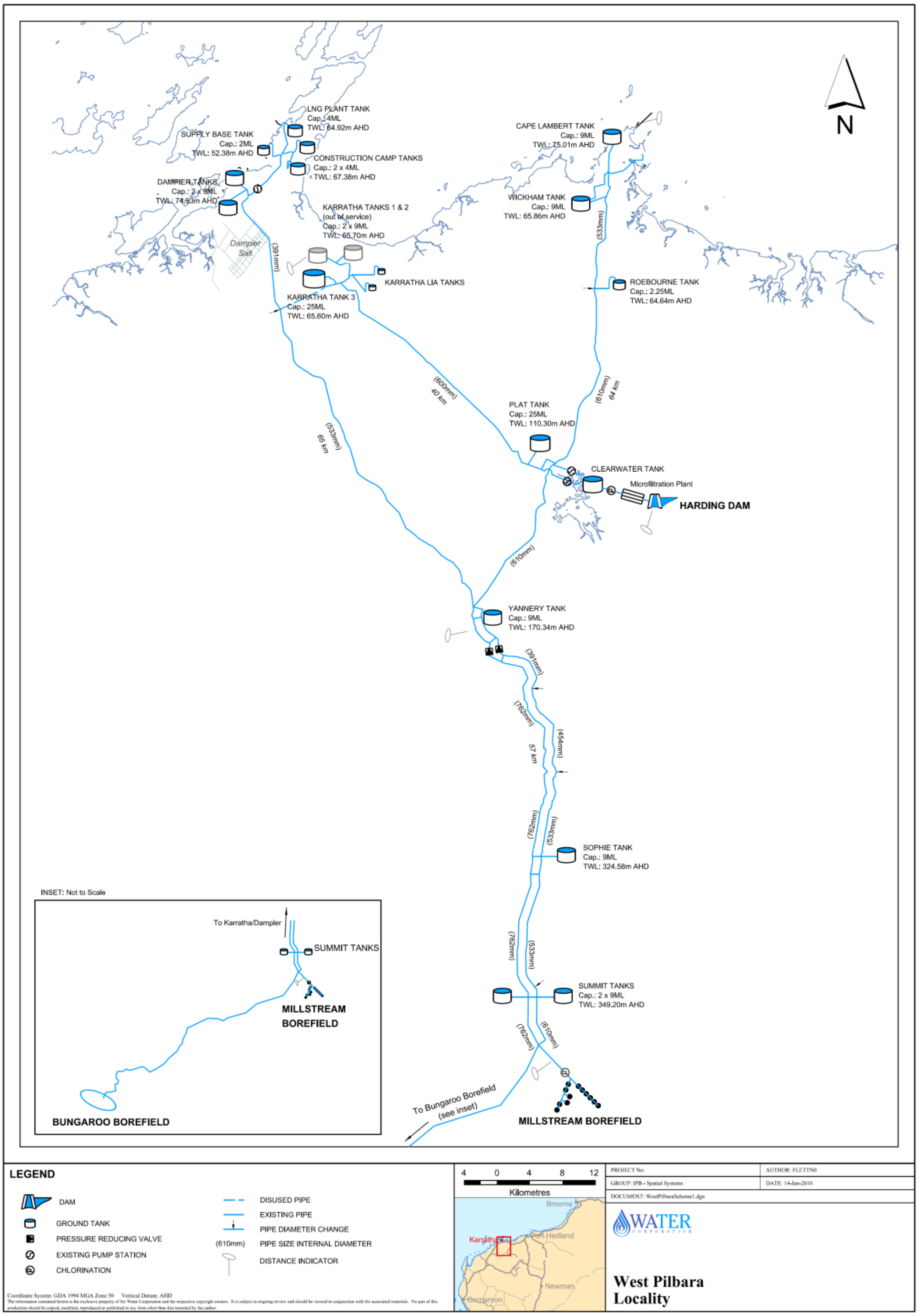

Figure 1 Locality plan

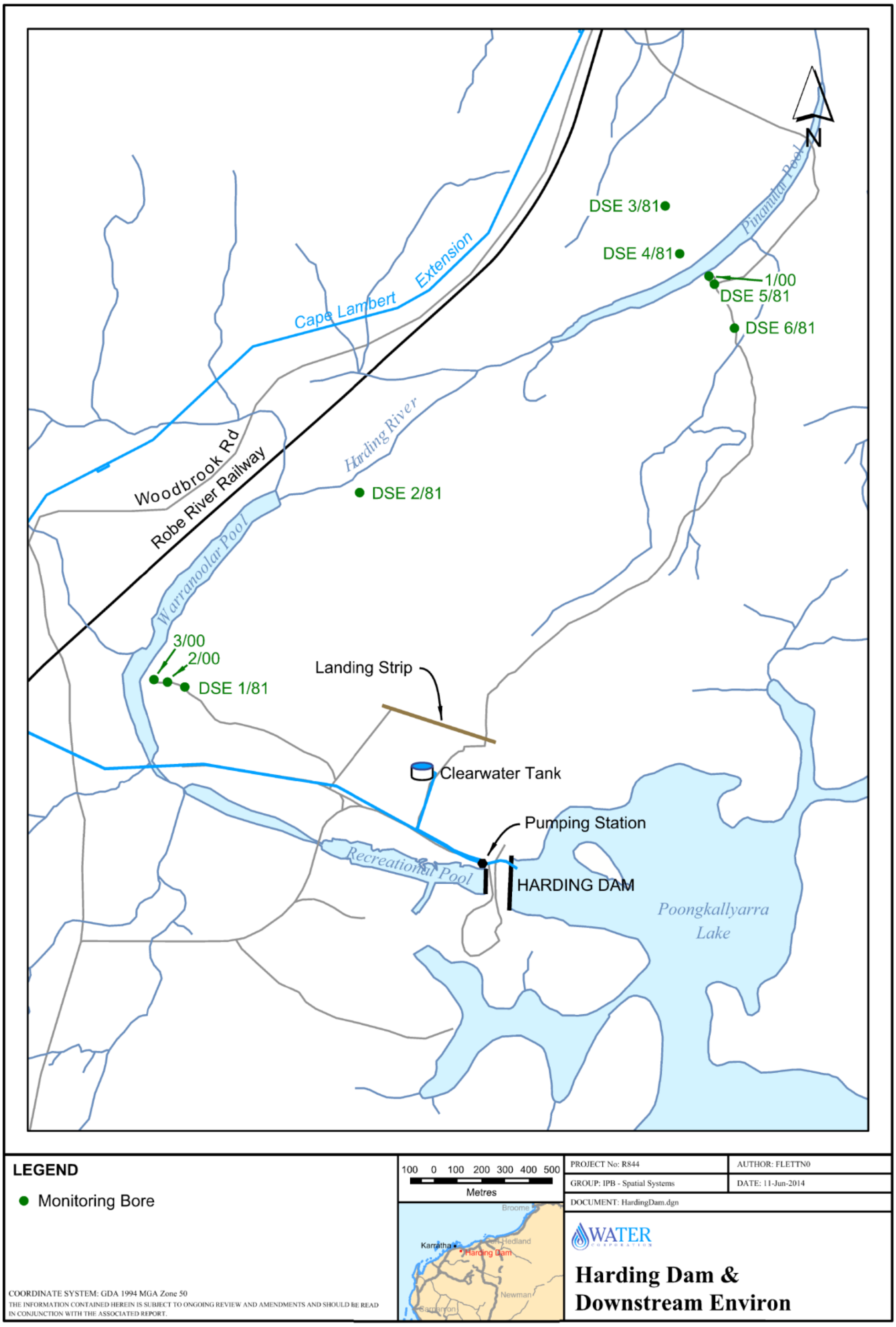

Figure 2 Harding Dam Environs

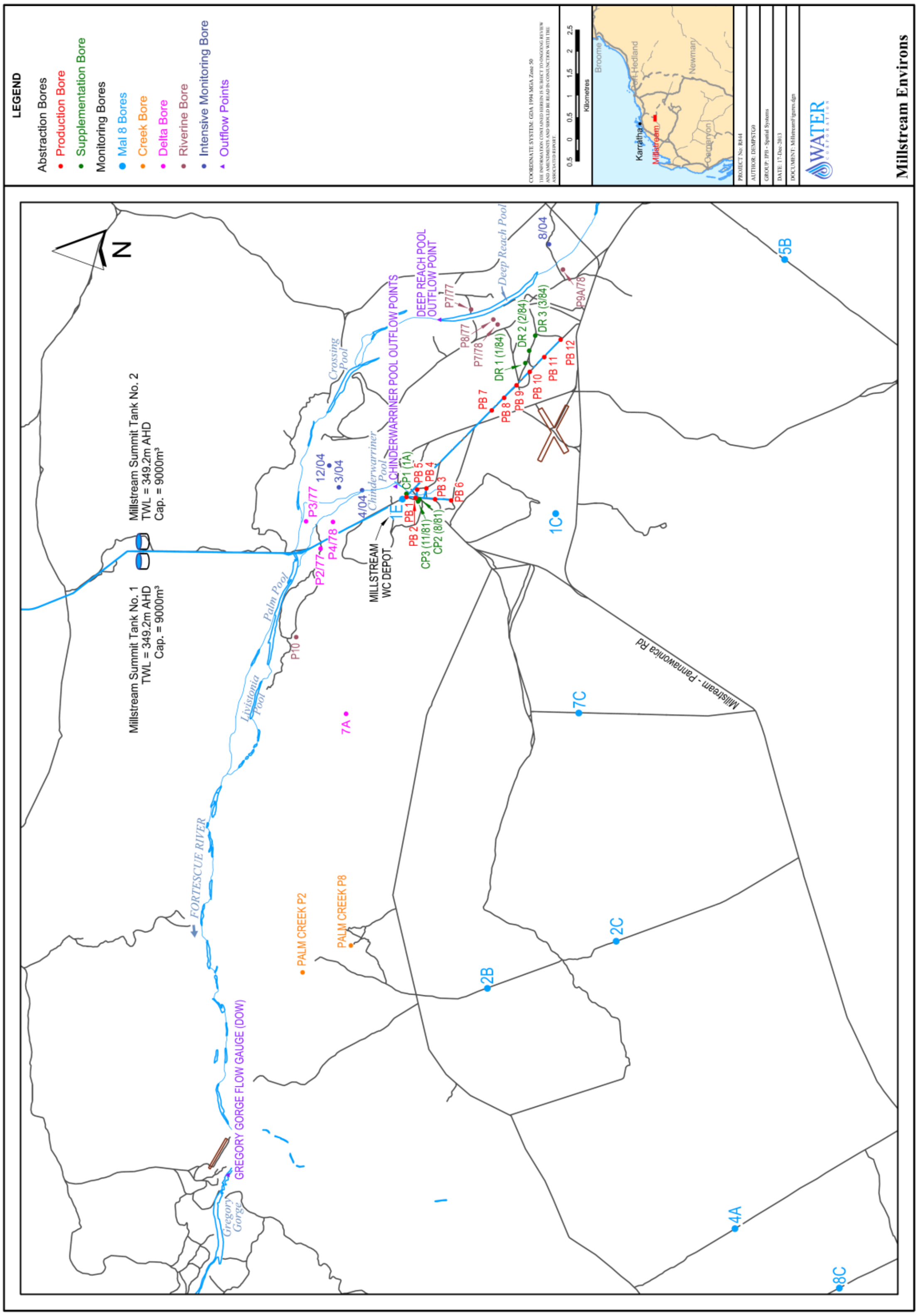

Figure 3 Millstream Environs

2. ADMINISTRATION

2.1 Period of Strategy

This strategy relates to the West Pilbara Water Supply Scheme and the duration of this operating strategy aligns with the licence duration. A draft operating strategy will be submitted with the licence renewal. The strategy will be reviewed under the following circumstances:

i) Prior to the licence expiry date;

ii) if water monitoring summaries or reviews indicate adverse trends or unexpected performance;

iii) if a significant change to the asset or strategy is required;

iv) if directed by DoW.

2.2 Definition of Water Year

The water year for this scheme is 1 May to 30 April.

Prior to this WRMOS, the water year for the West Pilbara Water Supply Scheme was 1 April to 31 March. The water year was changed to bring this WRMOS in line with the Pilbara Groundwater Allocation Plan, October 2013. This allows the water year to better align with the wet season which is defined as finishing in April.

2.3 Reporting

The Corporation will submit the following for this scheme:

1. An advanced Water Monitoring Summary to the DoW by 31 July each year as per Appendix E.
2. An advanced Water Monitoring Review to the DoW by 31 October 2015, as per Appendix 3 of the reporting guidelines.
3. Regular updates to support the Millstream Harding Technical Working Group and Millstream Harding Consultative Committee meetings as per Appendix F.
4. Bi-monthly monitoring will be supplied in excel format to DoW within 15 working days of collection when possible as per Appendix G. The Corporation will advise the DoW if this reporting requirement cannot be met due to extreme weather conditions.

2.4 Non-compliance with Strategy

Details of non-compliances or potential non-compliances of the licence conditions including this WRMOS and corresponding remedial action will be reported to the DoW Pilbara Office within 14 calendar days of the non-compliance being detected. In addition, the next water monitoring summary will make reference to any non-compliances reported during the water year and will report on corresponding remedial action and actions and measures to mitigate further non-compliances.

2.5 Contact Persons

Table 2 Contact Persons

Water Corporation	Department of Water
Perth Contacts	**Perth Contacts**
Senior Engineer, Policy and Compliance Infrastructure Planning Branch Policy and Compliance Group Water Corporation 629 Newcastle Street LEEDERVILLE, WA, 6007. Telephone: 9420 2744 PO Box 100 LEEDERVILLE WA 6902	Program Manager Regulation Division Regional Delivery and Regulation Department of Water Level 4 168 St Georges Terrace PERTH, WA, 6000 Telephone: 6364 6869 PO Box K822 PERTH WA 6842
Regional Contacts	**Regional Contacts**
Manager Service Delivery North West Region Water Corporation 16 De Grey Place KARRATHA, WA, 6714 Telephone: 9186 8280 PO Box 84 KARRATHA, WA, 6714	Program Manager Licensing and Water Use Department of Water Lot 4608 Cherratta Road KARRATHA, WA, 6714 Telephone: 9144 0200 PO Box 836 KARRATHA, WA, 6714

2.6 Millstream Harding Consultative Committee

Management of the West Pilbara Water Supply Scheme sources is a collaborative undertaking. The following organisations are involved in management of these sources and their environs:

Water Corporation (WC)

- Manages the timely provision, operation and maintenance of appropriate infrastructure solutions to maintain water supply reliability to existing and future customers within the strategic precincts serviced by the West Pilbara Water Supply Scheme.

Department of Water (DoW)

- Manages the water resources of Western Australia for the benefit of present and future generations, in partnership with the community.

Department of Parks and Wildlife (DPaW), formerly the Department of Environment and Conservation (DEC)

- Manages Millstream Chichester National Park, conserving native plants and animals and managing their sustainable use.

Traditional Owner Group

- Develops, maintains and improves traditional connection with the surrounding land.

These organisations are represented on the Millstream Harding Consultative Committee (MHCC), which was set up to provide strategic advice to the DoW on management issues associated with Harding Dam and Millstream Borefield. The MHCC meets annually. The DoW Regional Manager chairs the meeting, and the DoW is responsible for organising the meeting and taking and distributing minutes.

2.7 Technical Working Group

A subgroup of the MHCC, the Millstream Harding Technical Working Group (TWG) comprises operational and regional staff from WC, DoW and DPaW. TWG members are involved in the day-to-day operation, monitoring and management of Harding Dam and Millstream Borefield and their environs.

The group meets bi-monthly when the Millstream borefield MAL is above 293.80 mAHD to discuss ongoing management and monitoring issues and can recommend changes to associated programs to the MHCC for their endorsement. Meetings will increase to monthly when MAL is below 293.80 mAHD.

The Corporation will provide a monitoring results and abstraction update at the Technical Working Group's monthly/bi-monthly meetings. The monitoring data the Corporation provides includes MAL, spring discharge and actual and projected abstraction from both sources. The DoW sets the agenda and arranges the minutes for this meeting.

3. HYDROGEOLOGY

3.1 Millstream Geology

The Millstream aquifer is formed from a succession of Cainozoic alluvial, colluvial and lacustrine sediments of which calcrete (dolomite), with well developed solution cavities, is the major aquifer (Barnett and Commander, 1985). The sediments occupy a broad palaeovalley between the Hamersley Range and the Chichester Range.

3.2 Millstream Hydrogeology

3.2.1 Groundwater flow and discharge

The regional groundwater flow is from the south-east to north and the average annual fluctuation in water level is about 0.5 m (URS, 2007). To the east of Deep Reach groundwater flows in the direction of the river; west of Deep Reach Pool the groundwater flow direction is predominantly south to north. About 20km to the south west of Palm Springs a groundwater divide exists, beyond which the groundwater flows south west towards Robe River.

The primary groundwater discharge area from the aquifer is around Deep Reach Pool where the Fortescue River has cut directly into the dolomite. Much smaller quantities of groundwater also discharge from the Millstream dolomite into Chinderwarriner Pool, Woodley Creek, Palm Springs, and Peters Creek where these creek systems have eroded into the edges of the dolomite formation.

Evapotranspiration is a major discharge mechanism from the aquifer and rates of 550 to 3,700 mm/yr have been reported in the Millstream Management Plan (Welker Environmental Consultancy, 1998).

3.2.2 Recharge

Recharge to the Millstream aquifer occurs in the following ways:

1. Infiltration from flood flows in the Fortescue River (upstream of Deep Reach Pool)
2. Direct infiltration of rainfall
3. Infiltration from runoff via creeks (northern flank of Hamersley Range)
4. Through flow from the flanking sediments

Large recharge events typically occur with high river flows. A good example of this is in December 1975 when cyclone Joan passed through the area. No rainfall was recorded in the Millstream area, so the aquifer recharge that occurred (in the order of 50 GL – Barnett and Commander, 1985) was via direct infiltration from river flood flows generated higher up in the catchment.

Direct rainfall recharge to the aquifer had been estimated to range from 3 to 16 GL/a (Barnett and Commander, 1985) depending on rainfall location. The long term sustainable yield of the Millstream borefield has been determined by the DoW to be 6 GL/year.

The DoW has developed recharge classes that relate annual river flow to the proceeding years groundwater trigger levels as represented by MAL. Analysis of historical data and groundwater model (SKM 2010) outputs has allowed recharge events to be put into classes and the subsequent year's water availability into three categories:

1. high riverflow and aquifer recharge, resulting in average to wet conditions the following year;
2. low riverflow and aquifer recharge across one to two years resulting in average to dry conditions the following year; or
3. low riverflow and aquifer recharge across three or more years resulting in drought conditions.

Table 3 outlines the general relationships between the river flow regime and the following years MAL.

Table 3 General relationships between the river flow regime and MAL years

Riverflow (Gregory Gorge gauging station)	Water availability condition	MAL in following year
> 43GL	Above median	>293.80 mAHD
<43GL for 1 to 2 years	Dry	>293.60 mAHD
<43GL for 3 or > years	Drought	>293.50 mAHD

These relationships have been used to develop recharge classes, a set of variable environmental criteria / trigger levels, associated monitoring and management steps which may include stopping production despite being within the Millstream licence allocation limit. This is discussed in detail in section 6.2.

3.2.3 Water Quality

The variation in salinity in the Millstream Aquifer is reflective of the type of recharge and discharge mechanisms at work in different parts of the aquifer.

Where the Millstream dolomite outcrops and is incised by the Fortescue River (from Deep Reach Pool to 35 km upstream of this point) salinities reach over 1,200 mg/L TDS. It is believed that the elevated salinity levels may be a result of evapotranspiration from vegetation along the banks of the Fortescue River (Welker Environmental Consultancy, 1998) or that the high salinities are due to the recharge of brackish water from the Fortescue River during flood events (Barnett and Commander, 1985). It is likely that a combination of the two processes contribute to the levels observed.

Where the Millstream dolomite is overlain by Kangiangi Clay salinities in the dolomite area are generally under 500mg/L TDS. There is low discharge in this area and recharge occurs by rain filtering around the edge of the clays, through the Robe Pisolite into the underlying dolomite.

The DoW have set a performance indicator to maintain water quality, as an average across equipped bores, below 900 mg/L TDS and a target for unequipped production bores below the historical 95th percentile.

3.3 Harding Dam

3.3.1 Harding Dam Catchment Hydrology

The Harding Dam Catchment covers part of the north-west of the Hamersley Basin and has an area of approximately 1,100 km^2. The mean annual flow in the Harding Catchment is 38 GL/yr (Dames and Moore, 1982). Rainfall runoff is high due to the intense rainfall events generated by cyclone activity and the relatively impervious nature of the catchment.

At full capacity the water level in the dam lies at 60 mAHD resulting in a storage capacity of 63.8 GL and a surface area of 14 km^2. The minimum hydraulic operating level is approximately 47mAHD, which leaves 5GL storage. However, water quality issues (e.g., high inorganics) typically result in cessation of abstraction with 20GL storage.

Salinity levels in the dam range from 100 to 500 mg/L.

4. OPERATING RULES

Table 4 Operating rules

Parameter	Operating Rules
Annual abstraction	1. Annual abstraction under licences SWL 105715 and GWL 105696 will not exceed 15,000,000 kL in total. 2. The Corporation will submit to the DoW the volume of water taken within the year by 31 July each year.
Source operations	3. Harding Dam is to be operated as the primary source with supplementation from the Millstream borefield. The trigger for using Milstream borefield is the quality of water in Harding Dam and the water treatment plant's ability to meet drinking water guidelines and/or for operational reasons such as infrastructure damage. 4. The draw from Millstream during periods of concurrent use is not to exceed 2GL/year. The Corporation will provide justification for the concurrent use to the DoW within seven calender days. 5. The Corporation will advise DoW's Pilbara Regional Office when a change in source use is imminent. The advice will be provided one month prior to implementation under normal operational conditions. 6. If sources need to be changed because of an unforseen emergency, the Corporation will advise DoW within seven calender days, indicating the nature of the emergency and the estimated period of operation. 7. Abstraction from and monitoring of the Millstream borefield is conducted in accordance with the management framework as detailed in Section 6.2 and Table 15. 8. The frequency of the monitoring program may be increased if triggered by the management framework. Any changes from the baseline pool outflow monitoring frequency will occur after consultation with the technical working group. Final discretion rests with DoW and will be made after DoW's consideration of the cost-benefit of additional monitoring. If there is any change to the baseline monitoring frequency this will be reflected in an addendum that will apply until the following June or if there is a significant recharge event that results in criteria/triggers no longer being exceeded.
Production bore meters	9. Each production bore must have a cumulative water meter of a type approved under the *Rights in Water and Irrigation (Approved Meters) Order 2009*. 10. The meters must be installed in accordance with the provisions in the *Guidelines for Water Meter Installation 2009* before any water is taken (except for test pumping prior to commissioning). 11. The installed meters accuracy must be maintained within plus or minus 5% of the volume metered, in field conditions. This will be achieved by the use of magflow meters and having in place maintenance plans for these meters in accordance with Maintenance Standards. *See Note 1 below. 12. Volume readings will be taken as close as practicable to the end of each month. Should there be an unforseen event preventing volume readings being taken then the Corporation will notify the DoW. Notification to include an estimated date when readings can be taken. 13. The DoW must be notified in writing of any water meter malfunction within seven calender days of the malfunction being noticed. 14. Should a meter malfunction, and/or is to be removed then the Corporation will formally notify the DoW providing a timeline to rectify malfunction, or replace the meter and explain how abstraction is proposed to be measured during period of meter removal. 15. Any water meter changes that have occurred during the water year must be detailed in the Water Monitoring Summary. Current water meter details for each production bore are detailed in Appendix B.

***Note 1: Meter Maintenance Standards**

Mechanical meters

Mechanical water meters fitted onto production bores, or used for measurement on other water sources are purchased factory certified +/- 2% accuracy (complies with ATS4747) and 1% of meters purchased are acceptance tested by the Corporation (NATA certified facility). Meters that become faulty are replaced with factory calibrated meters, therefore on site calibration checks of mechanical meters is not required. This means that until all sites are equipped with modified pipework and magflow meters (Australian Technical Standard (ATS) 4747 compliant), existing sites with mechanical turbine meters installed prior to ATS4747 standards are managed as follows:

- Replacement using factory calibrated and certified mechanical meters (+/- 2% accuracy) when they fail or reach the end of their accurate life. Accurate life has been determined on advice from the Corporation (NATA certified) laboratory and is based on achieving +/- 5% accuracy over the meter life based on throughput and meter size.
- The Corporation has implemented a program to spend $500,000 a year on replacing mechanical meters with magflow meters. The program commenced in 2011 and will run for 5 years. This is over and above meter replacement due to meter failure or end of life. Replacement priority for the 5 year program is determined primarily by the level of scheme complexity and demand/supply pressures.

Magflow meters (note this section does not apply to mechanical meters)

The Corporation Technical Requirements (specified in Design Standards) require that the abstraction flowmeter shall comply with DS 25-01, the relevant parts of DoW *Guidelines for water meter installation 2009*, relevant parts of Australian Technical Standard (ATS) 4747 and the following:

- It shall be a magnetic full bore type complying with ATS 4747.2;
- Suitable for low flow/no flow conditions;
- The same diameter as the adjacent pipework;
- Located in pipework that it is always full of water (flowmeter is located downstream of the surface non return valve in order to remain submerged under); and
- Installed as close as possible to the abstraction point except for riverbed applications and upstream of any tees, takeoffs, diversions or branches in order to record all water abstracted from the bore.

5. MONITORING

The monitoring program for compliance with the licences for the West Pilbara Water Supply Scheme is outlined in the following sections. The monitoring requirements can be categorised as:

- Normal / regular monitoring includes scheme abstraction, water levels and water quality that is used from a resource assessment and sustainability perspective; and
- Intensive / increased monitoring of Millstream as triggered by the management framework set out in the DoW's *Pilbara groundwater allocation plan (October 2013)* to protect Millstream's ecological values.

5.1 Scheme Monitoring Requirements

Scheme monitoring requirements are:

Table 5 Scheme Monitoring Program

Frequency	Requirement
Annually	• Domestic consumption per unit • Unaccounted water

5.2 Harding Dam Monitoring Requirements

5.2.1 Harding Dam

Hydrological monitoring requirements for Harding Dam are as follows:

Table 6 Harding Dam Monitoring Program

Frequency	Requirement
Daily	• Reservoir water level • Scour valve discharge to Recreation Pool (Records of opening and closing of valve. Metred volume of discharge not required) • Rainfall (Water Corporation Harding Dam rainfall gauging station)
Every month	• Abstraction • Basic reservoir water quality components sampled from the water treatment plant raw water (pH, cond., turbidity and colour) * • Supernatant discharge to Recreation Pool (Metered volume not required. Only provide estimated as 5% of inflow into water treatment plant) • Recreational Pool water level
Every 6 months	• Reservoir water quality major components • Supernatant discharge water quality major components (Measured at discharge point at Recreational Pool, not supernatant discharge itself as this is via a sealed underground main)

Note * Frequency reduced from weekly to monthly since commissioning of microfiltration treatment plant

5.2.2 Harding River Downstream Environ

Monitoring requirements for Harding Dam downstream environ are:

Table 7 Harding Dam Environ Monitoring Program

Frequency	Requirement
Every 2 months	• Water level - Pinannular and Waranoolar Pools (derived from monitoring bores 1/00, 2/00 and 3/00) • Water rest levels - monitoring bores DSE1/81, DSE2/81, DSE3/81, DSE4/81, DSE5/81*, DSE6/81

* The Water Corporation will continue to monitor groundwater and pool water levels and report groundwater levels in Bore 5/81 against the trigger of 32.5 mAHD. If this trigger is reached the Corporation in consultation with the technical working group will determine if any action is required.

The DoW are currently reviewing the vegetation monitoring program for downstream environment of Harding Dam. This will include an alternative vegetation monitoring program to replace the vegetation photo point monitoring which ceased in 2011. Any recommended change in vegetation monitoring will be discussed at the TWG and if implemented reflected in an addendum to this WRMOS.

5.3 Millstream Borefield Monitoring Requirements

5.3.1 Millstream Aquifer

This monitoring program is consistent with the DoW's *Monitoring program to support the Pilbara groundwater allocation plan (October 2013)*. Monitoring requirements for the Millstream aquifer are:

Table 8 Millstream Aquifer Monitoring Program

Frequency	Requirement
Every month *or annually in November if the bore is not in operation since the start of the water year*	• Production bore water rest levels, abstraction and conductivity* (as TDS mg/L and all samples tested in the lab) Millstream Production bores (equipped) – PB1, PB2, PB3, PB4, PB5, PB6, PB7, PB8
Every month when in use	• Deep Reach and Chinderwarriner Supplementation bore water rest levels, bore abstraction and conductivity (TDS mg/L and all samples tested in the lab) Deep Reach supplementation bores – DR1(1/84), DR2(2/84), DR3(3/84) Chinderwarriner supplementation bores – CP1(1A), CP2(8/81), CP3(11/81)
Every 2 months *or frequency to increase to monthly when MAL below 293.8 m AHD*	• Water rest levels in monitoring bores MAL8 bores – 1C, 1E, 2B, 2C, 4A, 5B, 7C, 8C • Water rest levels in monitoring bore 7A
Annually	• All production bore (equipped) water quality major components

* DoW have set a performance indicator to maintain water quality, as an average across equipped bores, below 900 mg/L TDS and a target for production bore PB7 and PB8 below the historical 95th percentile..

5.3.2 *Millstream Environs*

Monitoring requirements for the Millstream environs are outlined below. Note the frequency may increase if trigger by the management framework described in Section 6.2.

Table 9 Millstream Environs Monitoring Program

Frequency	Requirement
Millstream Delta	
Every 2 months	• Chinderwariner Pool – Salinity as TDS and outflow (kL/s) *Frequency of above pool outflow monitoring to increase to fortnightly when triggered by Management Framework* * • Water rest levels - monitoring bores P2/77, P3/77, P4/78, 03/04, 12/04, 04/04 *Frequency to increase to monthly when triggered by the Management Framework*
Creeks	
Every 2 months	• Peters, Woodley and Palm Creeks outflow rate (kL/s) • Water rest levels in monitoring bores P2, P8
Riverine Area	
Every 2 months	• Deep Reach Pool – water quality (TDS) and outflow rate (kL/s) *Frequency of above pool outflow monitoring to increase to fortnightly when triggered by the Management Framework* * • Water rest levels in monitoring bores P8/77, P7/78, 08/04, P10 (DoW bore), P7/77, P9A/78 *Frequency to increase to monthly when triggered by the Management Framework*
Climate (BoM Station 5012)	
Daily	• Rainfall and pan evaporation
Millstream Environ - vegetation	
Annually in November	The Millstream environmental monitoring program will be implemented by a joint venture between the Corporation, DPaW, and DoW as detailed in Appendix D. The DoW will report on the program annually at the MHCC meeting. This report will include a summary of the previous years' budgets and a forecast of the coming years' budget. Additional costs above those detailed in Appendix D will be subject to agreement from the Corporation.

Note: * Any changes from the baseline pool outflow monitoring frequency will occur after consultation with the technical working group. Final discretion rests with DoW and will be made after DoW's consideration of the cost-benefit of additional monitoring.

The monitoring data is to be presented annually as per the template provided in Appendix E.

Where possible production bores will be rested for at least 10 minutes prior to water levels being recorded, if measuring as rested. If this is not possible then water levels will be reported as pump affected.

Water quality samples are to be prepared and transported in accordance with the current version of the Corporation's *Drinking Water Sampling Procedures* which complies with relevant Australian Standards. If the bore pump has not operated for some time then it is to be operated for at least 10 minutes (i.e. the equivalent time to pump 3 casing volumes) before a sample is taken.

5.4 Water Quality Monitoring

Major components to be measured for both Harding Dam and Millstream include alkalinity (as $CaCO_3$), aluminium (unfiltered), calcium, chloride, colour, conductivity, filterable organic carbon, hardness (as $CaCO_3$), iron (unfiltered), magnesium, manganese, nitrate, pH, potassium, salinity, silica (as SiO_2), sodium, sulphate, total filterable solids (TFSS) and turbidity.

Basic components for Harding Dam reservoir water include pH, conductivity, turbidity and colour.

The Corporation has in general adopted the *National Health and Medical Research Centre (NHMRC) Australian Drinking Water Guidelines 2011* (ADWG 2011) health guideline values for physical and chemical characteristics as the measures against which its drinking water quality performance will be assessed and reported to regulators.

The Corporation has adopted the ADWG 2011 aesthetic guideline values for physical and chemical characteristics as targets for aesthetic drinking water quality. The Corporation aims to achieve these aesthetic guideline values where possible.

The Corporation shall establish and manage a contract or agreement with each laboratory approved to perform analysis of assessable drinking water quality monitoring samples. All laboratories that undertake analysis of water samples shall have National Association of Testing Authorities, Australia (NATA) accreditation in the required field of testing, unless agreed with the Department of Health.

6. ENVIRONMENTAL WATER PROVISIONS

6.1 Harding River Environmental Water Provisions

Research commissioned by the Corporation recommended that when groundwater levels in bore 5/81 dropped below 32.5 mAHD, sufficient dam water should be released to reach a pool water stage height of 35 mAHD at Pinanular Pool (Streamtec, 1998). This recommendation was designed to meet the environmental water requirement (EWR) of the riparian vegetation of the Harding Dam.

This research also concluded that water quality, and in particular dissolved oxygen was the major determinant of biodiversity in the downstream pools and recommended a minimum water volume in Pinanular Pool of 65 ML. This was not equated to a stage height or a flow volume as the information was not available at the time.

A trial release conducted during the summer of 2001/2002 (Water Corporation, 2004) showed there was a strong but transitory link between surface water and groundwater levels and maintaining elevated groundwater levels would require substantial and continuous river flows.

There have been no prescribed environmental water releases since commissioning of the dam.

Given the findings on the ecological health of the pools and the results of the trial release, it is anticipated prescribed releases from Harding Dam will not be required over the life of this operating strategy.

The Corporation will continue to monitor groundwater and pool water levels and report groundwater levels in bore 5/81 against the trigger of 32.5 mAHD. If this trigger is reached the Corporation in consultation with the technical working group will determine if any action is required.

6.2 Millstream Environmental Water Provisions

The DoW's *Pilbara groundwater allocation plan (2013)* outlines water abstraction rules that have been developed to minimise the impacts on the ecosystem. The plan sets out Millstream aquifer EWRs, variable criteria (that account for a range of water availability conditions) and the steps that need to be taken each year by the Corporation to determine the level of monitoring. The following flow chart outlines the steps involved in determining if additional monitoring is required above the baseline.

The Corporation will conduct monitoring as detailed in Table 8 and Table 9.

The management framework described in this operating strategy is consistent with the Pilbara groundwater allocation plan. The allocation plan also sets out management steps required if criteria or trigger levels are reached in the pools and monitoring bores. This includes supplementation of pool flow from the operation of supplementation bores.

In the case were criteria or trigger levels are reached and Millstream is not in use, supplementation and/or additional monitoring may still be triggered if abstraction is reasonably assumed to have attributed to these levels being reached. This will be determined in consultation with TWG.

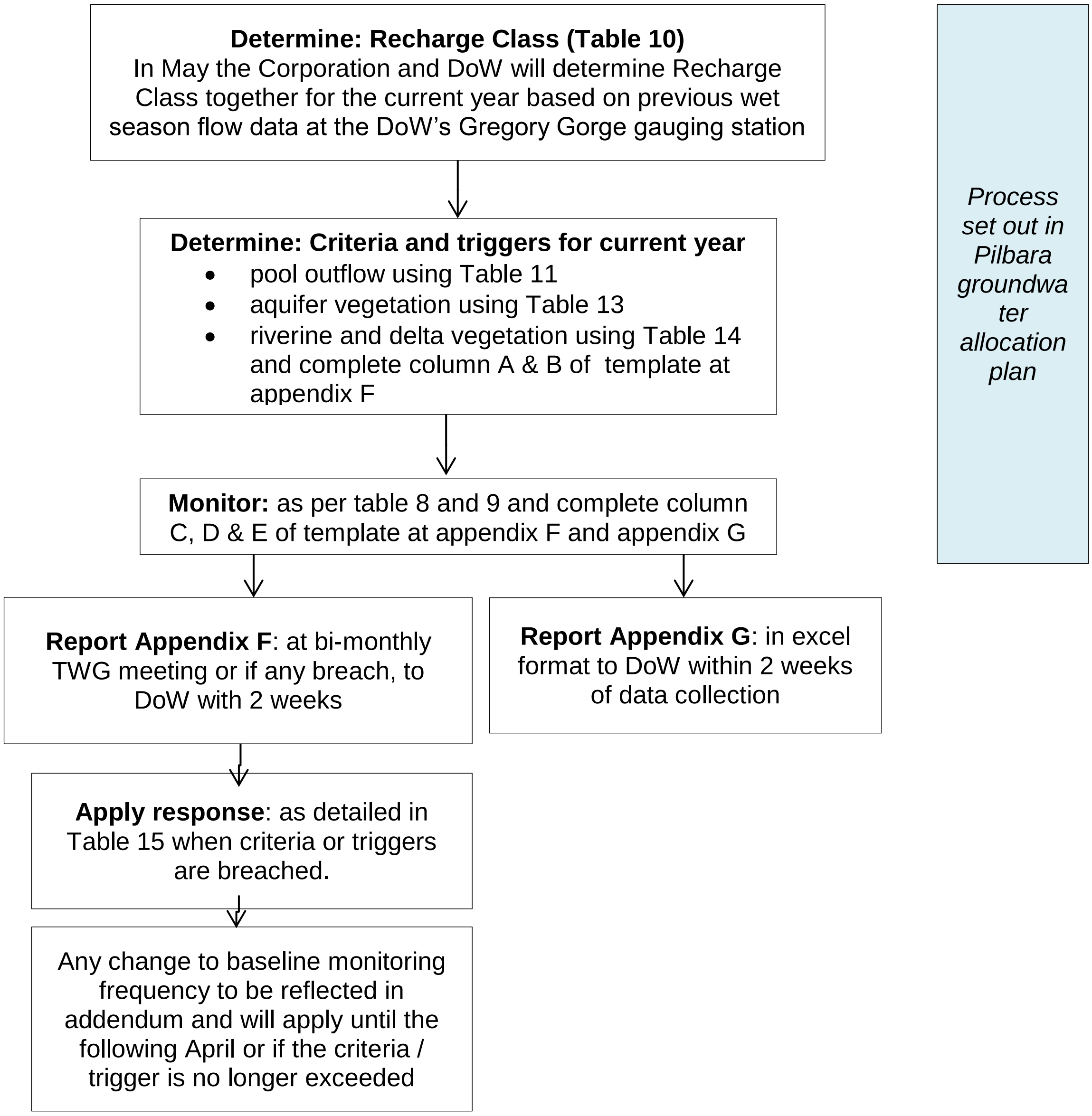

Figure 4 Flow chart of Millstream monitoring program above baseline

6.2.1 Recharge class

River flow is used to define water availability, or the year's recharge class (Table 10), and determines which criteria should be applied in any given year (Table 13,Table 14). Criteria for the current year is determined each June by joint agreement between the DoW and the Corporation based on the previous years' wet season flow (December–April) measured at Gregory Gorge gauging station. DoW are responsible for the monitoring of this gauging station and will provide the Corporation the validated data set by the 30th May. The data will be circulated by DoW to members of the TWG for reference. In some cases verified data will not be available until the 30th June, in which case unverified data will be used in the interim and the recharge class confirmed when verified data becomes available.

Table 10 Recharge class - water availability based on wet season flow

Recharge class	Water availability condition	Total wet season flows (Dec–April) ML @ Gregory Gorge gauging station
1	Drought	< 43,000 for previous 3 or more years
2	Dry	< 43,000 for previous 1 or 2 years
3	Average to wet / above median	> 43,000

Criteria are applicable to manage impacts to water dependent environments and can be summarised as:

- *minimum rates of pool outflow* to ensure the environmental demand of the downstream wetlands is met;
- *minimum aquifer groundwater levels* to ensure the water table across the aquifer does not drop below the root depth of groundwater-dependent vegetation; and
- *minimum local groundwater levels* to ensure the water table in the riverine and delta area does not drop below the root depth of groundwater dependent vegetation.

6.2.2 Pool outflow criteria – Wetlands (Spring discharge rates)

Pool outflow criteria have been set for Chinderwarriner and Deep Reach pools (Table 11). The variable criteria have been developed to maintain spring discharge rates into wetland areas downstream of these pools and incorporate variability in water conditions consistent with that historically experienced across Millstream.

In addition to criteria, trigger levels have been set to allow lead time for management responses to be implemented before critical drought levels are breached.

Table 11 Criteria for Pool outflows to maintain Millstream wetlands

Applicable criteria	Recharge Class			
	1 **5th %ile Drought criteria**	**1** **15th %ile Drought Trigger**	**2** **20th %ile Dry Criteria**	**3** **50th %ile Average/wet Criteria**
Wetlands				
Deep Reach Pool discharge	≥0.20kL/s	≥0.22kL/s		≥0.26kL/s
Chinderwar-riner Pool discharge	≥0.11kL/s	≥0.14kL/s	≥0.16kL/s	≥0.21kL/s

A set of targets have also been developed to ensure that criteria are set at adequate levels to maintain the functionality of the whole system (Table 12). Targets are to be reported on only and <u>do not have a compliance function</u>, however non-compliances may represent an area where future investigations or management action is required.

Table 12 Targets for water distribution and water quality across Millstream wetlands

Applicable target	Measure	Recharge Class 1 5th %ile Drought criteria	 2 20th ile Dry Criteria	 3 50th ile Average/wet Criteria
Allowable period of no flow at Gregory Gorge*	flow	period of no flow ≤1 month	period of no flow ≤3 months	period of no flow ≤ 5 month
Deep Reach water quality	TDS	≤1,400mg/L		
Chinderwarriner pool	TDS	≤1,086mg/L		

Note: * Measured by DoW but Water Corporation is required to report against targets.

6.2.3 Aquifer groundwater level criteria to support riparian vegetation

Groundwater level criteria have been set to maintain aquifer groundwater levels and support riparian vegetation which is directly dependent on the aquifer. MAL, calculated as the average from eight bores across the aquifer, is used to represent water availability conditions for aquifer riparian vegetation.

Again, variable criteria and trigger levels have been set to account for a range of water availability conditions (as determined through recharge classes) and allow lead time for management responses to be implemented before critical drought levels are breached (Table 13).

Table 13 Groundwater level criteria to support aquifer riparian vegetation

Applicable criteria	Measure	Recharge Class 1 5th %ile Drought criteria	 1 15th ile Drought Trigger	 2 20th ile Dry Criteria	 3 50th ile Average/wet Criteria
Aquifer vegetation					
MAL8*	Average MAL8 ground-water level	≥293.50 mAHD	≥293.57 mAHD	≥293.60 mAHD	≥293.80 mAHD

* The MAL 8 bores also represent 08/04, 1E, P7/78, P8/77, Palm Spring P8.

6.2.4 Riverine and delta groundwater level criteria

Riverine and delta vegetation is supported by local groundwater levels which are largely recharged by pool outflows. However because local groundwater levels can also be influenced by several other factors, local groundwater level criteria have been set (in addition to pool outflow rates) to ensure groundwater levels are maintained and riverine and delta vegetation is supported (Table 14). These triggers and criteria are fixed and do not vary with recharge classes.

Table 14 Groundwater level criteria to support riverine and delta riparian vegetation

Applicable criteria	5th %ile Criteria	20th ile Trigger	50th ile Trigger
Riverine and delta vegetation			
P10 (Riverine)	≥270.07mAHD	≥270.28mAHD	≥270.70mAHD
P7/77(Riverine)	≥290.46mAHD	≥290.70mAHD	≥291.02mAHD
03/04 (Delta)	≥285.76mAHD	≥285.81mAHD	≥285.86mAHD
12/04 (Delta)	≥283.96mAHD	≥284.14mAHD	≥284.27mAHD
04/04 (Delta)	≥287.32mAHD	≥287.43mAHD	≥287.65mAHD
P2/77 (Delta)	≥278.70mAHD	≥279.28mAHD	≥279.73mAHD
P3/77 (Delta)	≥278.01mAHD	≥278.20mAHD	≥278.35mAHD
P4/78 (Delta)	≥283.22mAHD	≥283.51mAHD	≥283.79mAHD
Palm Springs P2	≥278.74mAHD	≥278.80mAHD	≥278.93mAHD

6.3 Adaptive Environmental Assessment and Management

For Millstream the criteria have been included in a trigger and response management framework. The framework incorporates reporting, monitoring, ecological supplementation and management of take from the borefield – with increasing levels of effort as levels or flows fall (Table 15).

If water levels drop below the criteria set for that year (based on recharge class), management actions which have been set for the subsequent recharge class automatically apply. Any changes from the baseline pool outflow monitoring frequency will occur after consultation with the technical working group. Final discretion rests with DoW and will be made after DoW's consideration of the cost-benefit of additional monitoring.

Table 15 Responses when criteria are breached for Millstream aquifer

Response	Wetlands (Spring discharge rates)				Aquifer vegetation (GW levels)				Riverine and delta vegetation (GW levels)		
	Recharge class				Recharge class				(Classes not applicable)		
	3	2	1		3	2	1		50th %tile Trigger	20th %tile Trigger	5th %tile Criteria
	(Wet)	(Dry)	(Drought)		(Wet)	(Dry)	(Drought)				
	Criteria	Criteria	Trigger	Criteria	Criteria	Criteria	Trigger	Criteria			
1. Monitoring and reporting:											
◦ increase frequency of groundwater or flow monitoring****	✓	✓	✓		✓	✓	✓		✓***	✓	✓
◦ increase reporting to department and technical working group	✓	✓	✓		✓	✓	✓		✓***	✓	✓
◦ commence downstream flow monitoring	✓	✓	✓								
◦ commence additional vegetation monitoring						✓	✓			✓	✓
2. Supplementation plan:											
◦ Trigger supplementation plan	✓*	✓	✓							✓**	
3. Local response:											
◦ spread take across bore field		✓	✓			✓	✓				
4. Scheme response:											
◦ Consider spread across scheme			✓				✓			✓	
◦ Commence negotiations with Rio Tinto to use Bungaroo as contingency water source if taking from Harding is not sustainable			✓				✓			✓	
5. Critical response:											
◦ commence supplementation		✓	✓**								✓**
◦ reduce take			✓					✓**			✓
◦ use contingency sources			✓					✓**			✓

* This response should only be triggered at this level if flow from Livistona Pool has ceased or flow across the Delta is insufficient to reach the Fortescue River or feed into the Delta marshes.
** This response can be triggered earlier if monitoring indicates that ecosystems are responding to reduced water availability.
*** These actions to follow channel check by DPaW to ensure blockages are not causing reduced flows
**** Any change from baseline pool outflow monitoring will occur after consultation with the technical working group, Final discretion rests with DoW and will be made after DoW's consideration of the cost-benefit of additional monitoring.
Please refer to Appendix C for a copy of the Supplementation Plan

6.4 Adaptive Environmental Assessment and Management

Adaptive environmental assessment and management, through improved knowledge obtained from monitoring data or scientific evaluation, which refines interim environmental water provisions, should result in improvements being incorporated into the management guidelines as early as practicable. DoW manages the revision process for EWP on behalf of the Environmental Protection Authority in consultation with:

- The Millstream Harding Consultative Committee (MHCC)
- The MHCC Technical Working Group

Examples of where revisions to EWP may be required are:

- Relocation of monitoring sites or establishment of new sites
- Loss of existing monitoring sites (e.g. collapse of the toe end of a pool)
- Development of more representative monitoring points
- Improved knowledge of aquifer and pool hydrological processes

7. CONTINGENCY PLANS

7.1 Contingency Sources

It is unlikely a contingency source will be required in the next 10- 20years for the West Pilbara scheme because the estimated demand will only be 7 GL/year (out of an annual allocation of 15 GL/year) when Bungaroo comes on line to service Rio Tinto's water demand.

If a contingency source is required Bungaroo Creek borefield could potentially be utilised as a contingency source option for this scheme, subject to negotiations with Rio Tinto.

Should water be required for emergency purposes then negotiations with Rio Tinto Iron Ore for access to their supply will commence. Access would depend on prevailing operational and economic factors. If abstraction from the contingency source is expected to exceed the licensed allocation, negotiations with Rio Tinto Iron Ore for an increased supply will occur and a licence increase will be sought from DoW.

7.2 Drought

A drought management plan is not required for this scheme within the life of this operating strategy. At current and predicted future levels of abstraction it is considered that there is adequate capacity in Harding Dam and Millstream borefield to cater for annual rainfall variations without the need for a drought management plan. During periods of prolonged below average rainfall water restrictions may be imposed.

7.3 Flooding

Harding Dam is taken offline during overflow of the dam and supply for the scheme is sourced from Millstream Borefield. This is due to numerous reasons including the following;

- limited access to the treatment plant as access is via a causeway which is inundated during a flooding event;
- Water quality in the dam as Turbidity increases after large inflows; and
- Potential inundation of the water pump station in extreme overflows. During such an event the pumps need to be removed to prevent damage.

Once the flood waters have receded the scheme is switched back to supply from Harding Dam. Flooding of Millstream area is not expected to prevent operation of Millstream Borefield.

7.4 Water Quality

If water quality is observed to be exhibiting an adverse trend, as assessed by a groundwater professional, then an investigation will be carried out and reported on in water monitoring summaries to DoW. A reduction in abstraction from the current source, change in the spread of abstraction across the scheme and/or a re-evaluation of the resource and a revision of planning will be considered, in consultation with the DoW, if professional assessment indicates that action is required prior to the next scheduled Water Monitoring Review.

7.5 Annual Allocation

If annual abstraction reaches 90% of the licensed entitlement, the Corporation will review the predicted future levels of abstraction and implement all appropriate water efficiency and water loss minimisation measures.

If abstraction is forecast to exceed the licensed entitlement for a specific year only then approval will be obtained from the DoW before exceedance of the entitlement occurs.

If abstraction is forecast to permanently exceed the licensed entitlement the Corporation will seek an increase to the on-going licensed entitlement.

7.6 Bore Failure

In the event of the failure of a production bore, the *Rights in Water Irrigation Act, 1914* Act requires that an application is made to DoW and approval given by way of a 26D licence before redrilling proceeds. Bore log and construction details will be supplied to the DoW in the prescribed Form 2 or 2A within one month after completion of the redrill. A bore redrill will not initiate a revision of this WRMOS. Details of production bore redrills will be included in the next WRMOS/ Water Monitoring Review.

Should it be deemed that a failed production bore will not be redrilled or utilised as a monitoring bore then it shall be decommissioned as per the methodology described in section 18 of the Minimum Construction Requirements for Water Bore in Australia (National Uniform Driller Licensing Committee, 2012).

8. WATER USE EFFICIENCY

As part of *Water Forever*, the Corporation has established a goal of reducing water use by 15% for both the Integrated Water Supply Scheme (IWSS) and regional schemes by 2030.

The Corporation has developed a Regional Water Efficiency Strategy to identify and prioritise regional schemes that would benefit most from tailored water efficiency programs.

The Corporation also continues to implement a Statewide program promoting the efficient use of water, including:

- as of 1 October 2007, standard restrictions apply for all domestic consumers throughout Western Australia. For West Pilbara Water Supply Scheme customers, use of sprinklers is restricted to alternate days;
- installation of Smart Meters to allow more frequent and remote monitoring of water usage, enabling leaks to be detected early;
- providing a wide range of Waterwise Programs to promote the use of water efficient products for indoor and outdoor household use;
- influencing customer behaviour by providing water efficiency information that is simple to employ;
- supporting and leading the establishment of a nationally endorsed, mandatory water efficiency labelling and standards scheme;
- running the Water Efficiency Management Plan (WEMP) program, which requires all non-residential customers throughout the state using more than 20,000 kL per year to produce a WEMP and provide annual progress reports;
- supporting an education service to schools so that water related learning can be integrated into the school curriculum; and
- a rising block tariff structure to discourage wastage of water.

The Corporation will regularly monitor the domestic consumption per unit and the level of unaccounted water for the scheme. This will be reported in the Water Monitoring Summary. If the level of unaccounted water is found to exceed the Corporation's target of 15% an investigation will be undertaken to identify the reason for this and every endeavour will be made to reduce the level to below the target.

9. COMMITMENTS

No	Commitment	Responsibility	Timeline
1	Review of this strategy.	IPB	Prior tolicence expiry date
2	Submit to DoW Pilbara Office a Water Monitoring Summary as per Appendix E.	Region/IPB	31 July each year
3	Submit to DoW Pilbara Office a Water Monitoring Review as per Appendix 3 of the reporting guidelines.	IPB	31 August 2015
4	Regular updates to support the Millstream Harding Technical Working Group and the Millstream Harding Consultative Committee meetings as per Appendix F.	Region	Ongoing
5	Bi-monthly monitoring will be supplied in excel format to DoW within 15 working days of collection when possible as per Appendix G. The Corporation will advise the DoW if this reporting requirement cannot be met due to extreme weather conditions.	Region	Ongoing
6	Details of non-compliances or potential non-compliances and corresponding remedial action will be reported to DoW Pilbara Office.	Region/IPB	Within 14 calender days of non-compliance being detected
7	Annual combined abstraction will not exceed 15,000,000 kL and the Corporation will submit to the DoW the volume of water taken within the year by 31 July each year. The predicted future levels of abstraction will be reviewed when abstraction reaches 90% of the licensed entitlement. If abstraction is forecast to exceed the entitlement for a single year only the Corporation will obtain approval from DoW prior to the exceedence. If abstraction is forecast to permanently exceed the entitlement the Corporation will submit an application to increase the entitlement to the DoW Pilbara office.	Region	When abstraction reaches 90% of the licensed entitlement.
8	The Corporation will operate the source as per "source operations" operating rules outlined in Table 4.	Region	Ongoing
9	Each production bore must have a cumulative water meter of a type approved under the *Rights in Water and Irrigation (Approved Meters) Order 2009*.	Region	Ongoing
10	Water meters must be installed in accordance with the provisions of the document entitled *Guidelines for Water Meter Installation 2009* before any water is taken (except for test pumping prior to commissioning).	Region	Ongoing
11	Installed water meter accuracy must be maintained within plus or minus 5% of the volume metered, in field conditions.	Region	Ongoing
12	DoW must be notified in writing of any water meter malfunction.	Region	Within seven calender days of the malfunction being noticed
13	Should a meter malfunction, and/or is to be removed then the Corporation will formally notify the DoW providing a timeline to rectify malfunction, or replace	Region	Ongoing

No	Commitment	Responsibility	Timeline
	the meter and explain how abstraction is proposed to be measured during period of meter removal.		
14	Any water meter change that has occurred during the water year must be detailed in the Water Monitoring Summary.	Region	31 July each year
15	Water meter details for each production bore must be maintained at all times.	Region	Ongoing
16	Monitoring as specified in Section 5 and 6 will be undertaken. Every effort will be made to ensure monitoring occurs in the nominated month. Should there be an unforeseen event preventing readings being taken, the Corporation will resume monitoring as soon as practical. Volume readings will be taken as close as practicable to the end of each month. Should there be there be an unforseen event preventing volume readings being taken then the Corporation will notify the DoW. Notification to include an estimated date when readings can be taken.	Region	Ongoing
17	The Corporation will implement the management responses specified in Table 15 in accordance with the details set out in section 6.2. Any changes from the baseline pool outflow monitoring frequency will occur after consultation with the technical working group. Final discretion rests with DoW and will be made after DoW's consideration of the cost-benefit of additional monitoring.	Region/IPB	Ongoing
18	Provide validated data from Gregory Gorge gauging station so the Corporation can determine the coming year's recharge class.	DoW	30th May each year
19	If water quality is observed to be exhibiting an adverse trend, as assessed by a groundwater professional, then an investigation will be carried out and reported on in annual statements to DoW. A reduction in abstraction from the current source, change in the spread of abstraction across the borefield and/or a re-evaluation of the resource and a revision of planning will be considered, in consultation with the DoW, when professional assessment indicates that action is required prior to the next scheduled Water Monitoring Review.	Region/IPB	Ongoing
20	If the annual abstraction for the scheme is approaching the licensed entitlement then, before an application for an increase is submitted, the Corporation will ensure that unaccounted losses are within acceptable limits and that water use efficiency is promoted to customers.	Region/IPB	Ongoing
21	In the event of the failure of a production bore, a replacement cannot be redrilled until an application to the DoW has been made and subsequent approval given. Bore log and construction details will be supplied to the DoW Pilbara Office in the prescribed Form 2 or 2A within one month after completion of the redrill.	Region/IPB	Ongoing

No	Commitment	Responsibility	Timeline
22	The level of unaccounted for water for the scheme will be reported in the Water Monitoring Summary. If the level of unaccounted for water is found to exceed the Corporation's target of 15%, then an investigation will be undertaken to identify the reasons for this and the Corporation will endeavour to reduce the level to below the target.	Region	31 July each year
23	The Corporation will comply with this strategy as a condition of Surface water Licence Number 105715 and Groundwater Licence Number 105696 for the taking of water from the West Pilbara Water Supply Scheme.	Region	Ongoing
24	Determine of recharge class	DoW and Region	By 30 June each year
25	DoW must be notified in writing if concurrent use is to exceed 2 GL/year	Region	Within seven calender days
26	DoW must be notified in writing when a change in source use is imminent	Region	One month prior to change under normal operational conditions or within seven calender days in emergency situations
27	Report on Millstream Environ vegetation monitoring program	DoW	Annually at MHCC meeting

10. REFERENCES

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APPENDICES

APPENDIX A - Bore Details

BORE DETAILS					
Bore Number	**PB1**	**PB2**	**PB3**	**PB4**	**PB5**
Date Drilled	1969	1969	1969	1969	1969
Bore Type	Production	Production	Production	Production	Production
SWRIS Number	G70818230	G70818231	G70818232	G70818233	G70818234
Zone	50	50	50	50	50
MGA Easting	506887.9	506887.9	506887.9	507137.9	507137.9
MGA Northing	7612105.6	7611855.6	7611405.6	7611655.6	7611905.6

BORE CONSTRUCTION					
Casing Diameter (mm)	394	406	406	394	394
Casing Depth (mbtoc)	24.8	20.9	28.3	23.2	23.2
Casing Type	Steel	Steel	Steel	Steel	Steel
Screen/Slot Interval (m)	9.10-22.00	45.90-18.10	16.50-24.80	9.10-20.50	9.40-21.30
Screen/Slots	Slots	Slots	Slots	Slots	Slots
SWL at Drilling (mbtoc)	5.16	2.72	9.84	4.9	5.46

REDUCED LEVELS					
Height Datum	AHD	AHD	AHD	AHD	AHD
Top of Casing (m)	299.1	296.67	301.17	298.76	299.21
Bottom of Hole (m)	274.3	275.77	272.87	275.56	276.01
Top of Screens (m)	290	250.77	284.67	289.66	289.81
Bottom of Screens (m)	277.1	278.57	276.37	278.26	277.91

EQUIPPING DETAILS					
Pump Type	Submersible	Submersible	Turbine	Turbine	Turbine
Pump Installation Date	29/11/2000	10/03/1992	30/11/1994	03/04/1985	17/01/1985
Pump Capacity (kL/day)		18000	17040	7850	9024
Pump Suction (m)		13.96	12.71		
Bottom of Motor (mbtoc)				10.04	
Airline Depth (mbtoc)	N/A	N/A	N/A	N/A	N/A
Available Drawdown (m)		7.67	4.65	2.56	4.57
Comments					

PUMPING TEST RESULTS					
Pump Test Rate (kL/day)	5,400	5,400	5,500	5,400	5,400
Specific Capacity (m3/day/m)					
Recommended (kL/day)	17,743	17,774	17,698	8,980	8,879
Long-term Drawdown (m)	0.1	0.8	0.6	1.8	0.3
Comments	Immediate recovery	Immediate recovery	30 second recovery	30 second recovery	3 minute recovery

PRODUCTION					
Pumping 2011/12 (kL)	303,174	76,213	551,540	86,619	761,424
Hours Pumped	413	97	988	294	2,256
Ave Output (kL/day)	17,618	18,857	13,401	7,071	8,100

BORE DETAILS					
Bore Number	**PB6**	**PB7**	**PB8**	**PB9**	**PB10**
Date Drilled	1969	1971	1971	1971	1971
Bore Type	Abstraction	Abstraction	Abstraction	Unequipped production	Unequipped production
SWRIS Number	G70818235	G70818236	G70818237	G70818238	G70818239
Zone	50	50	50	50	50
MGA Easting	507137.9	508937.8	509187.8	509487.8	509787.8
MGA Northing	7611906	7610206	7609956	7609656	7609356

BORE CONSTRUCTION					
Casing Diameter (mm)	394	406	406	406	406
Casing Depth (btoc)	23.8	33.3	32.5	36.2	31.9
Casing Type	Steel	Steel	Steel	Steel	Steel
Screen/Slot Interval (m)	11.20-21.10	21.90-32.70	20.30-31.70	22.00-33.10	15.20-29.10
Screen/Slots	Slots	Slots	Slots	Slots	Slots
SWL at Drilling (mbtoc)	7.2	14.77	14.54	14	11.45

REDUCED LEVELS					
Height Datum	AHD	AHD	AHD	AHD	AHD
Top of Casing (m)	306.29	308.66	308.62	308.13	305.53
Bottom of Hole (m)	282.49	275.36	276.12	271.93	273.63
Top of Screens (m)	295.09	286.76	288.32	286.13	290.33
Bottom of Screens (m)	285.19	275.96	276.92	275.03	276.43

EQUIPPING DETAILS					
Pump Type	Turbine	Turbine	Turbine	Turbine	Turbine
Pump Installation Date	05/12/1985	20/02/1992	29/04/1987		15/04/1982
Pump Capacity (kL/day)	7200	7680	7728	7200	6960
Pump Suction (m)	17.68				
Bottom of Motor (mbtoc)					
Airline Depth (mbtoc)	N/A	N/A	N/A	N/A	N/A
Available Drawdown (m)	13.49	4.8	3.41	3.79	4.39
Comments					

PUMPING TEST RESULTS					
Pump Test Rate (kL/day)	5,400	5,500	5,500	5,500	5,500
Specific Capacity (m3/day/m)					
Recommended (kL/day)	8,838	8,911	8,887	8,923	8,809
Long-term Drawdown (m)	0.3	Nil	Nil	Nil	0.1
Comments	3 minute recovery				Under 30 seconds recovery

PRODUCTION					
Pumping 2011/12 (kL)	86,112	371,317	376,646	N/A	N/A
Hours Pumped	245	7,887	1,351	N/A	N/A
Ave Output (kL/day)	8,439	1,130	6,690	N/A	N/A

BORE DETAILS					
Bore Number	**PB11**	**PB12**	**CP1 (A)**	**CP2 (8/81)**	**CP3 (11/81)**
Date Drilled	1971	1971		28/09/1981	19/10/1981
Bore Type	Unequipped production	Unequipped production	Supplementation	Supplementation	Supplementation
SWRIS Number	G70818240	G70818241	G70818005	G70818242	G70818243
Zone	50	50	50	50	50
MGA Easting	510087.8	510462.3	506956.4	506829	506778.8
MGA Northing	7609056	7608650	7612179.62	7611881.7	7611913

BORE CONSTRUCTION					
Casing Diameter (mm)	406	406	203	498	498
Casing Depth (mbtoc)	24.8	26	18	12.3	13.3
Casing Type	Steel	Steel	Steel	Steel	Steel
Screen/Slot Interval (m)	11.90-22.80	13.80-22.80	6.10 – 18.00	4.30 – 10.30	5.30 – 11.30
Screen/Slots			Slots	Slots	Slots
SWL at Drilling (mbtoc)	7.29	8.39		3.95	

REDUCED LEVELS					
Height Datum	AHD	AHD	AHD	AHD	AHD
Top of Casing (m)	287.6	288.8	296.32	296.96	297.85
Bottom of Hole (m)	262.8	262.8	278.32	284.66	284.55
Top of Screens (m)	275.7	275	290.22	292.66	292.55
Bottom of Screens (m)	264.8	266	278.32	286.66	286.55

EQUIPPING DETAILS					
Pump Type					
Pump Installation Date					
Pump Capacity (kL/day)					
Pump Suction (m)					
Bottom of Motor (mbtoc)					
Airline Depth (mbtoc)	N/A	N/A	N/A	N/A	N/A
Available Drawdown (m)	7.9	8.4			
Comments					

PUMPING TEST RESULTS					
Pump Test Rate (kL/day)	5,500	5,500	1,609	4,275	6,046
Specific Capacity (m3/day/m)					
Recommended (kL/day)	8,694	8,561		10000	
Long-term Drawdown (m)	0.25	0.5	0.2	0.9	5.02
Comments	30 second recovery	Under 30 second recovery	Immediate recovery	30 second recovery	30 second recovery

PRODUCTION					
Pumping 2011/12 (kL)	N/A	N/A	N/A	N/A	N/A
Hours Pumped	N/A	N/A	N/A	N/A	N/A
Ave Output (kL/day)	N/A	N/A	N/A	N/A	N/A

BORE DETAILS			
Bore Number	**DR1 (1/84)**	**DR2 (2/84)**	**DR3 (3/84)**
Date Drilled	19/06/1984	10/07/1984	31/07/1984
Bore Type	Supplementation	Supplementation	Supplementation
SWRIS Number	G70818244	G70818245	G70818246
Zone	50	50	50
MGA Easting	509935.1	510217.8	510561.8
MGA Northing	7609466.6	7609378.4	7609238.6

BORE CONSTRUCTION			
Casing Diameter (mm)	495	495	495
Casing Depth (mbtoc)	24.22	22.8	20.5
Casing Type	Steel	Steel	Steel
Screen/Slot Interval (m)	6.09 – 23.52	7.80 – 22.80	8.22 – 19.80
Screen/Slots	Slots	Slots	Slots
SWL at Drilling (mbtoc)		7.5	7

REDUCED LEVELS			
Height Datum	AHD	AHD	AHD
Top of Casing (m)	302.72	288.42	288.51
Bottom of Hole (m)	278.56	277.9	280.28
Top of Screens (m)	296.69	292.9	292.56
Bottom of Screens (m)	279.26	277.9	280.98

EQUIPPING DETAILS			
Pump Type			
Pump Installation Date			
Pump Capacity (kL/day)			
Pump Suction (m)			
Bottom of Motor (mbtoc)			
Airline Depth (mbtoc)	N/A	N/A	N/A
Available Drawdown (m)			
Comments			

PUMPING TEST RESULTS			
Pump Test Rate (kL/day)	12,150	13,080	13,080
Specific Capacity (m3/day/m)			
Recommended (kL/day)			
Long term Drawdown (m)	0.36	0.11	0.24
Comments	2 minute recovery	2 minute recovery	3 minute recovery

PRODUCTION			
Pumping 2011/12(kL)	N/A	N/A	N/A
Hours Pumped	N/A	N/A	N/A
Ave Output (kL/day)	N/A	N/A	N/A

BORE DETAILS					
Bore Number	**5B**	**1E**	**1C**	**7C**	**2B**
Date Drilled	1968	1979	1969	1968	1968
Bore Type	MAL 8 Monitoring	MAL 8 Monitoring	MAL 8 Monitoring	MAL 8 Monitoring	MAL 8 Monitoring
SWRIS Number	G70818002	G70818049	G70818007	G70818011	G70818013
Zone	50	50	50	50	50
MGA Easting	512299	506833.8	506646.2	501958.8	495681
MGA Northing	7603546	7612268	7608929	7608244	7610331

BORE CONSTRUCTION					
Casing Diameter (mm)	152		127	127	152
Casing Depth (m bTOC)	46		41	53	55
Casing Type					
Screen/Slot Interval (m bTOC)	22.50 – 28.50		12.00 – 18.00	19.00 – 37.00	12.00 – 18.00
Screen/Slots	Slots	Slots	Slots	Slots	Slots
SWL at Drilling (m bTOC)	19.66		10.97	22.1	21.44
Comments					

REDUCED LEVELS					
Height Datum	AHD	AHD	AHD	AHD	AHD
Top of Casing (m)	313.8	300.17	305.11	315.9	315.59
Bottom of Hole (m)	267.8		264.11	262.9	260.59
Top of Screens (m)	291.3		293.11	296.9	303.59
Bottom of Screens (m)	285.3		287.11	278.9	297.59

BORE DETAILS				
Bore Number	**2C**	**4A**	**8C**	**7A**
Date Drilled	1968	1968	1968	1968
Bore Type	MAL 8 Monitoring	MAL 8 Monitoring	MAL 8 Monitoring	MAL 8 Monitoring
SWRIS Number	G70818014	G70818017	G70818021	G70818009
Zone	50	50	50	50
MGA Easting	496755	490202.3	488845.4	502091.6
MGA Northing	7607391	7604681	7602298	7612994

BORE CONSTRUCTION				
Casing Diameter (mm)	127	152	152	127
Casing Depth (m bTOC)	59	57	49	38
Casing Type				
Screen/Slot Interval (m bTOC)	27.00 – 42.00	23.00 – 29.00	24.50 – 31.40	15.00 – 27.00
Screen/Slots	Slots	Slots		Slots
SWL at Drilling (m bTOC)	23.39	23.24	23.67	14.93
Comments				

REDUCED LEVELS				
Height Datum	AHD	AHD	AHD	AHD
Top of Casing (m)	317.17	316.67	317.59	308.71
Bottom of Hole (m)	258.17	259.67	268.59	270.71
Top of Screens (m)	290.17	293.67	293.09	293.71
Bottom of Screens (m)	275.17	287.67	286.19	281.71

BORE DETAILS					
Bore Number	**P8/77**	**P9/77**	**P1/78**	**P7/78**	**P9/78**
Date Drilled	29/09/1977	29/09/1977	20/09/1978	25/09/1978	25/09/1978
Bore Type	Riverine Monitoring	Riverine Monitoring	Riverine Monitoring	Riverine Monitoring	Riverine Monitoring
SWRIS Number	G70818119	G70818120	G70818123	G70818129	G70818130
Zone	50	50	50	50	50
MGA Easting	510931.6	512125.9	503855.9	510819	511918.2
MGA Northing	7610195.5	7608800.5	7615231.6	7610096.6	7608611.8

BORE CONSTRUCTION					
Casing Diameter (mm)					
Casing Depth (m bTOC)	5.84	5.54	7.78	3.07	2
Casing Type	PVC	PVC	PVC	PVC	PVC
Screen/Slot Interval (m bTOC)	0.94 – 5.84	0.54 – 5.00	1.32 – 7.32	0.75 – 3.07	0.80 – 2.00
Screen/Slots	Slots	Slotted	Slotted	Slotted	Slotted
SWL at Drilling (m bTOC)	2.26		2.91	2.47	1.78
Comments					

REDUCED LEVELS					
Height Datum	AHD	AHD	AHD	AHD	AHD
Top of Casing (m)	296.4	295.14	275.5	296.87	295.81
Bottom of Hole (m)	290.56	289.6	267.72	293.8	293.81
Top of Screens (m)	295.46	294.6	274.18	296.12	295.01
Bottom of Screens (m)	290.56	290.14	268.18	293.8	293.81

BORE DETAILS				
Bore Number	**P2/77**	**P3/77**	**P4/78**	**P10**
Date Drilled	22/09/1977	23/09/1977	21/09/1978	23/09/1975
Bore Type	Delta Monitoring	Delta Monitoring	Delta Monitoring	Riverine Monitoring
SWRIS Number	G70818113	G70818114	G70818126	N/A
Zone	50	50	50	50
MGA Easting	505704	506327	506313.6	
MGA Northing	7614139	7614469.6	7613855.5	

BORE CONSTRUCTION				
Casing Diameter (mm)				
Casing Depth (m bTOC)	17.67	12.24	6	13.43
Casing Type	PVC	PVC	PVC	PVC
Screen/Slot Interval (m bTOC)	2.78 – 17.67	1.15 – 12.24	0.45 – 6.00	3.13 – 13.43
Screen/Slots	Slotted	Slotted	Slotted	Slotted
SWL at Drilling (m bTOC)	3.57	2.32	2.82	3.61 (BNS)
Comments				

REDUCED LEVELS				
Height Datum	AHD	AHD	AHD	AHD
Top of Casing (m)	282.53	279.96	285.44	
Bottom of Hole (m)	264.86	267.72	279.44	
Top of Screens (m)	279.75	278.81	284.99	
Bottom of Screens (m)	264.86	267.72	279.44	

BORE DETAILS				
Bore Number	**P2**	**P4**	**P5**	**P8**
Date Drilled	14/10/1975	10/10/1975	12/10/1975	18/10/1975
Bore Type	Palm Creek Monitoring	Palm Creek Monitoring	Palm Creek Monitoring	Palm Creek Monitoring
SWRIS Number	G70818102	G70818103	G70818104	G70818108
Zone	50	50	50	50
MGA Easting	496044.7	496878.5	496611.6	496657.3
MGA Northing	7614547.3	7613930.1	7613954	7613446

BORE CONSTRUCTION				
Casing Diameter (mm)				
Casing Depth (m bTOC)	9	11.94	9.04	19.1
Casing Type	PVC	PVC	PVC	PVC
Screen/Slot Interval (m bTOC)	4.00 – 9.00	3.54 – 12.54	3.04 – 9.04	13.10 – 19.10
Screen/Slots	Slotted	Slotted	Slotted	Slotted
SWL at Drilling (m bTOC)	5.6			11.94
Comments				

REDUCED LEVELS				
Height Datum	AHD	AHD	AHD	AHD
Top of Casing (m)	282.55	298.6	293.16	306.72
Bottom of Hole (m)	273.55	286.66	284.12	287.62
Top of Screens (m)	278.55	295.06	290.12	293.62
Bottom of Screens (m)	273.55	286.06	284.12	287.62

BORE DETAILS					
Bore Number	**1/81**	**2/81**	**3/81**	**4/81**	**5/81**
Date Drilled	28/10/1981	27/10/1981	22/10/1981	28/10/1981	27/10/1981
Bore Type	Harding Dam Environmental Monitoring	Harding Dam Environmental Monitoring	Harding Dam Environmental Monitoring	Harding Dam Environmental Monitoring	Harding Dam Environmental Monitoring
SWRIS Number	G70919101	G70919102	G70919103	G70919104	G70919105
Zone	50	50	50	50	50
MGA Easting	509529.8	510266.5	511553.1	511614.1	511760.1
MGA Northing	7681117.6	7681936.8	7683144.4	7682943.1	7682814.6

BORE CONSTRUCTION					
Casing Diameter (mm)					
Casing Depth (m bTOC)	20.41	11.5	12	9.9	11.59
Casing Type	PVC	PVC	PVC	PVC	PVC
Screen/Slot Interval (m bTOC)	14.41 – 20.41	5.50 – 11.50	6.00 – 12.00	3.90 – 9.90	5.59 – 11.59
Screen/Slots	Slots	Slots	Slots	Slots	Slots
SWL at Drilling (m bTOC)	9.02	6.46	9.86	8.2	7.55
Comments					

REDUCED LEVELS					
Height Datum	AHD	AHD	AHD	AHD	AHD
Top of Casing (m)	45.16	42.31	43.26	41.21	39.1
Bottom of Hole (m)	24.75	30.81	31.26	31.31	27.51
Top of Screens (m)	30.75	36.81	37.26	37.31	33.51
Bottom of Screens (m)	24.75	30.81	31.26	31.31	27.51

BORE DETAILS				
Bore Number	**6/81**	**1/00 (Pinanular Pool)**	**2/00 (Warranoola Pool)**	**3/00 (Warranoola Pool)**
Date Drilled	24/10/1981	16/06/2000	17/06/2000	17/06/2000
Bore Type	Harding Dam Environmental Monitoring	Harding Dam Environmental Monitoring	Harding Dam Environmental Monitoring	Harding Dam Environmental Monitoring
SWRIS Number	G70919106	N/A	N/A	N/A
Zone	50	50	50	50
MGA Easting	511844.4	511737	509457	509400
MGA Northing	7682629.9	7682848.8	768138.5	7681148.9

BORE CONSTRUCTION				
Casing Diameter (mm)		53.7	53.7	53.7
Casing Depth (m bTOC)	9.61	9.7	10.5	7.6
Casing Type	PVC	PVC	PVC	PVC
Screen/Slot Interval (m bTOC)	3.61 – 9.61	3.70 – 9.68	4.50 – 10.50	1.60 – 7.60
Screen/Slots	Slots	Slots	Slots	Slots
SWL at Drilling (m bTOC)	7.84	2.89	4.3	3.35
Comments				

REDUCED LEVELS				
Height Datum	AHD	AHD	AHD	AHD
Top of Casing (m)	41.95	38.69	44.4	42.16
Bottom of Hole (m)	32.34	28.99	33.9	34.56
Top of Screens (m)	38.34	34.99	39.9	40.56
Bottom of Screens (m)	32.34	29.01	33.9	34.56

BORE DETAILS					
Bore Number	**1/04**	**2/04**	**3/04**	**4/04**	**5/04**
Date Drilled	20/11/2004	20/11/2004	21/11/2004	21/11/2004	21/11/2004
Bore Type	Deep Reach Monitoring	Deep Reach Monitoring	Deep Reach Monitoring	Deep Reach Monitoring	Deep Reach Monitoring
SWRIS Number	N/A	N/A	N/A	N/A	N/A
Zone	50	50	50	50	50
MGA Easting	508287	507627	507102	507306	506534
MGA Northing	7613631	7613163	7613719	7613190	7614124

BORE CONSTRUCTION					
Casing Diameter (mm)	50.5	50.5	50.5	50.5	50.5
Casing Depth (m bTOC)	3.8	11.5	2	1.5	1.5
Casing Type	PVC	PVC	PVC	PVC	PVC
Screen/Slot Interval (m bTOC)	3.80 – 7.80	11.50 – 15.50	2.00 – 5.00	1.50 – 5.00	1.50 – 5.00
Screen/Slots	Slotted	Slotted	Slotted	Slotted	Slotted
SWL at Drilling (m bTOC)	3.7	7.06	1.6	2	1
Comments					

REDUCED LEVELS					
Height Datum	AHD	AHD	AHD	AHD	AHD
Top of Casing (m)	286.48	294.36	287.22	289.39	284.23
Bottom of Hole (m)	278.68	278.86	282.22	284.39	279.23
Top of Screens (m)	282.18	282.86	285.72	287.89	282.73
Bottom of Screens (m)	278.18	278.86	282.22	284.39	279.23

BORE DETAILS					
Bore Number	**6/04**	**7/04**	**8/04**	**9/04**	**10/04**
Date Drilled	2004	22/11/2004	22/11/2004	28/11/2004	26/11/2004
Bore Type	Deep Reach Monitoring	Deep Reach Monitoring	Deep Reach Monitoring	Deep Reach Monitoring	Deep Reach Monitoring
SWRIS Number	N/A	N/A	N/A	N/A	N/A
Zone	50	50	50	50	50
MGA Easting	506779	511406	512646	513058	512646
MGA Northing	7613615	7609525	7608925	7608487	7608925

BORE CONSTRUCTION					
Casing Diameter (mm)	50.5	50.5	50.5	50.5	50.5
Casing Depth (m bTOC)	1.3	1.3	2.9	2.8	1.9
Casing Type	PVC	PVC	PVC	PVC	PVC
Screen/Slot Interval (m bTOC)	1.30 – 4.30	1.30 – 4.30	2.90 – 6.50	2.80 – 6.80	1.90 – 5.90
Screen/Slots	Slotted	Slotted	Slotted	Slotted	Slotted
SWL at Drilling (m bTOC)	1.2	0.8	2.5	3.7	2
Comments					

REDUCED LEVELS					
Height Datum	AHD	AHD	AHD	AHD	AHD
Top of Casing (m)	287.13	294.11	297.14	297.89	296.62
Bottom of Hole (m)	282.83	289.81	290.64	289.89	289.62
Top of Screens (m)	285.83	292.81	294.24	295.09	294.72
Bottom of Screens (m)	282.83	289.81	290.64	291.09	290.72

BORE DETAILS		
Bore Number	**11/04**	**12/04**
Date Drilled	27/11/2004	28/11/2004
Bore Type	Deep Reach Monitoring	Deep Reach Monitoring
SWRIS Number	N/A	N/A
Zone	50	50
MGA Easting	512646	507600
MGA Northing	7608925	7613939

BORE CONSTRUCTION		
Casing Diameter (mm)	50.5	50.5
Casing Depth (m bTOC)	2.4	1.14
Casing Type	PVC	PVC
Screen/Slot Interval (m bTOC)	2.40 – 6.40	1.14 – 3.14
Screen/Slots	Slotted	Slotted
SWL at Drilling (m bTOC)	1.9	1.06
Comments		

REDUCED LEVELS		
Height Datum	AHD	AHD
Top of Casing (m)	295.65	285.15
Bottom of Hole (m)	289.15	281.85
Top of Screens (m)	293.25	284.01
Bottom of Screens (m)	289.25	282.01

APPENDIX B - Water Meter Details

Bore	Meter Serial Number	Meter Type	Meter Make	Mechanical / Magnetic	Meter Size (mm)	Installation Date	Last Maintenance Calibration Date
PB1	O11905H440	SI	Siemens Magflow	Magnetic	400	30/06/2012	N/A
PB2	O11705H440	SI	Siemens Magflow	Magnetic	400	19/05/2011	N/A
PB3	O11805H440	SI	Siemens Magflow	Magnetic	400	19/05/2011	N/A
PB4	O11605H440	SI	Siemens Magflow	Magnetic	200	19/05/2011	N/A
PB5	O11605H440	SI	Siemens Magflow	Magnetic	200	29/05/2011	N/A
PB6	055205H470	SI	Siemens Magflow	Magnetic	200	29/05/2011	N/A
PB7	O11205H440	SI	Siemens Magflow	Magnetic	200	27/05/2011	N/A
PB8	A11405H440	SI	Siemens Magflow	Magnetic	200	27/05/2011	N/A

APPENDIX C - Supplementation Implementation Procedure for Chinderwarriner Pool and Deep Reach Pool

1. Purpose

The purpose of this Supplementation Implementation Procedure (SIP) is to provide guidance on identifying the approach of a flow criteria trigger, ensure the supplementation approval process is commenced in a timely manner and thereby reduce the amount of time between a trigger being reached and commencement of supplementation.

It outlines agency responsibilities, dissemination of information to key stakeholders (DPaW, WC and DoW) and provides a clearly defined process to be followed prior, during and after supplementation

2. Abbreviations

WC	Water Corporation
DoW	Department of Water
DPaW	Department of Parks and Wildlife
kL/s	Kilolitres per second
EWP	Environmental water provision
MAL	Mean aquifer level
MHCC	Millstream Harding Consultative Committee
SIP	Supplementation Implementation Procedure
TWG	Millstream Harding technical working group

3. General Monitoring and Reporting

Outflows from Chinderwarriner and Deep Reach (measured below Crossing Pool) are determined by bi-monthly discharge measurements taken during the 1st week of every second month. This monitoring is the responsibility of the Corporation and is reported against triggers, at bimonthly TWG meetings.

Groundwater levels in the riverine and delta area are also determined by bi-monthly bore level monitoring taken during the 1st week of every second month.

4. Initiation of Supplementation Implementation Procedure

If applicable trigger levels are reached (see Table 16), this Supplementation Implementation Procedure is activated as detailed below and outlined in the Supplementation Implementation Flow Chart (Attachment 1).

Table 16 Supplementation triggers and criteria

Ecological community	Recharge class	Trigger supplementation plan	Criteria	Commence supplementation	Criteria
Wetlands					
Chinder-warriner	3 and 2	0.16 kL/s	Dry criteria	0.14 kL/s	Drought trigger
	1	0.14 kL/s	Drought trigger	0.11 kL/s	Drought criteria
Deep Reach	3	0.26 kL/s	Dry criteria	0.22 kL/s	Drought trigger
	2 and 1	0.22 kL/s	Drought trigger	0.20 kL/s	Drought criteria
Riverine and delta vegetation					
P2	All years	278.80 mAHD	20th percentile	278.74 mAHD	5th percentile
P10	All years	270.28 mAHD	20th percentile	270.07 mAHD	5th percentile
P7/77	All years	290.70 mAHD	20th percentile	290.46 mAHD	5th percentile
03/04	All years	285.81 mAHD	20th percentile	285.76 mAHD	5th percentile
12/04	All years	284.14 mAHD	20th percentile	283.96 mAHD	5th percentile
04/04	All years	287.43 mAHD	20th percentile	287.32 mAHD	5th percentile
P2/77	All years	279.28 mAHD	20th percentile	278.70 mAHD	5th percentile
P3/77	All years	278.20 mAHD	20th percentile	278.01 mAHD	5th percentile
P4/78	All years	283.51 mAHD	20th percentile	283.22 mAHD	5th percentile

Current "best guess" suggests that these triggers will provide about 3 months notice prior to a breach of criteria. This will need to be verified once fortnightly monitoring commences and trends are established. It is expected that a period of 3 months will provide an adequate period of notice between the triggering of the SIP and a breach of the criteria to prepare approvals for supplementation from the traditional owners.

5. Actions prior to breach

The Corporation to organise meeting with TWG members to implement actions as follows:

Engage traditional owners

The Corporation in collaboration with DoW to initiate engagement with the Yindjibarndi traditional owners to advise them on the supplementation process.

Increase monitoring

The Corporation to increase monitoring at Crossing Pool and Chinderwarriner Pool to fortnightly. Results to be forwarded to the TWG after each measurement for review.

Agree on Supplementation

TWG to agree that supplementation is to commence if fortnightly results show that any outflow criteria has been reached. It is the responsibility of individual TWG representatives to gain approval from regional managers if required.

6. Actions during breach

Commencement of Supplementation

Commence supplementation into the pool which is being breached, at the calculated rate (ie Supplementation rate = Criteria – measured outflow). Continue fortnightly monitoring, adjusting supplementation rates as required.

Discontinue Supplementation

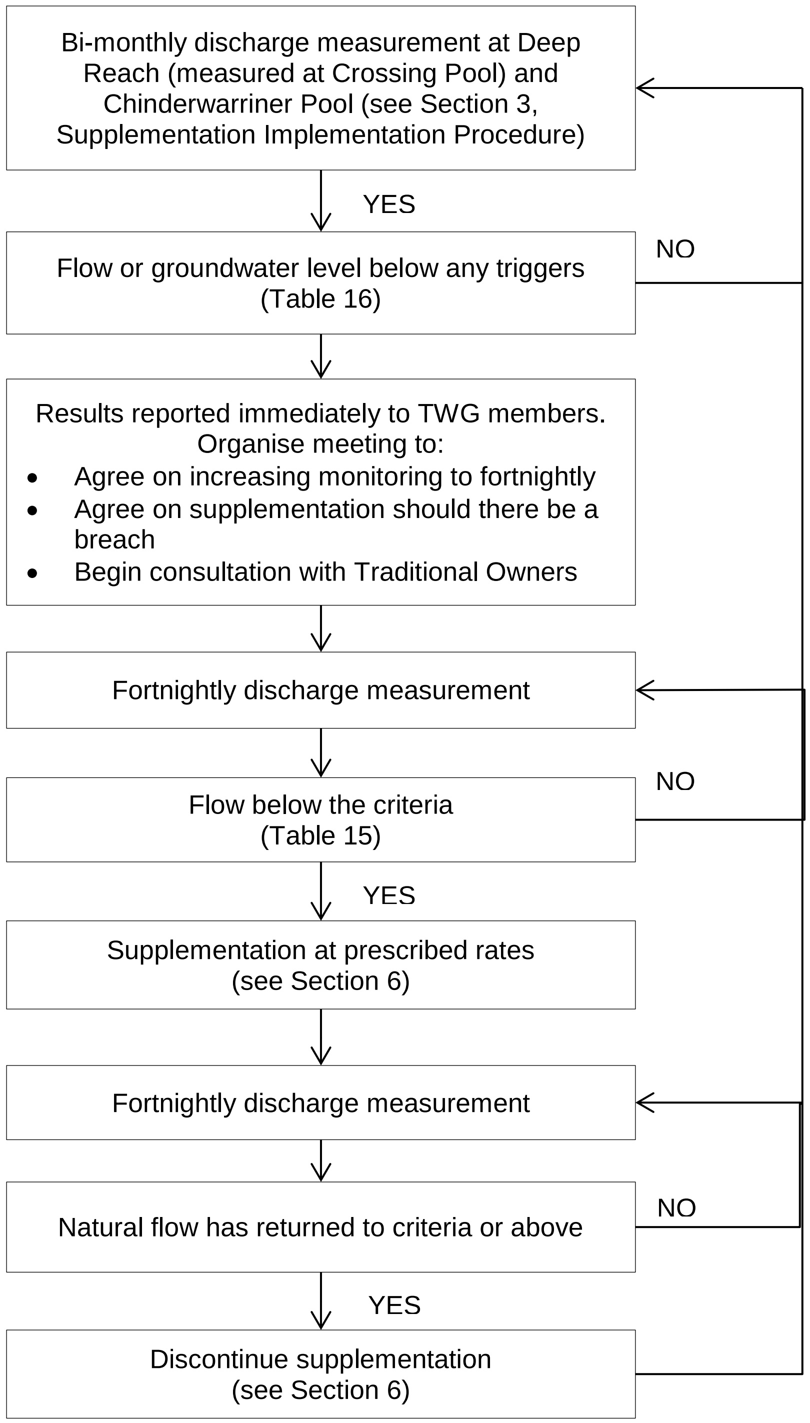
In the event of a recharge event and the return of natural flows to above criteria, supplementation will be discontinued. Fortnightly monitoring is to continue until flows exceed the triggers.

7. Attachments

Attachment 1 Supplementation Implementation Flow Chart

Attachment 1 - Supplementation Implementation Flow Chart

To be used in conjunction with the Supplementation Implementation Procedure



APPENDIX D - Millstream vegetation monitoring program

1. Context

DoW are reviewing the ecological water requirements of groundwater dependent ecosystems at Millstream as part of the Pilbara groundwater allocation plan. Linked to the review of EWR and as an outcome of the 2010 Millstream Harding Consultative Committee meeting, the Department is also reviewing the vegetation monitoring program for Millstream.

The vegetation monitoring program has undergone considerable modification and downgrading since it commenced in 1984. Previous methodologies were found to be overly intensive and provided limited information to support ongoing management. As such it is important that an informative and adequate monitoring program is established which is achievable and can be accomplished within available resources.

2. Monitoring objectives

Millstreams ecological values are intrinsically linked to the abundance and permanence of groundwater-derived spring flows and groundwater levels in the aquifer. These values are likely to be adversely affected by over abstraction from the aquifer.

The objective of groundwater dependent vegetation monitoring is to:

- determine if ecosystems respond to altered water availability as predicted and improve our understanding of response
- support the triggering of management actions where appropriate
- prevent abstraction induced impacts to the key ecological values

3. Current monitoring

Water Corporation has undertaken annual aerial photography of the management area intermittently since 1976. Currently this is the only form of vegetation monitoring being undertaken and whilst the data has continued to be captured the imagery has not been reviewed (reported on by DEC) since 2002.

4. Landsat monitoring review

In 2003 DEC (then CALM) developed a remote sensing tool using LandSat imagery to monitor vegetation cover (as percent foliage cover (PFC) and change in vegetation cover (Behn, Kendrick et al. 2007). PFC analysis was completed for all years from 1979 – 2005 (excluding 1980 and 1982) using archived LandSat imagery. Monitoring stopped in 2005 due to resourcing constraints.

An assessment of the effectiveness of remote sensing (Landsat) as a component of vegetation monitoring was completed in 2009-10. This compared outputs of the remote sensing against groundwater and surface water data. Statistical analysis concluded that the technique was moderately useful in detecting changes in PFC in relation to water availability. However the results were complicated by a number of other non-hydrological factors that were also found to influence PFC data such as erosion, weed removal, fire and flooding etc (Braimbridge, Antao et al. 2010). It is expected that these results could be improved with the addition of complementary on-ground vegetation monitoring and more timely assessment of outputs.

As a broad monitoring tool Landsat outputs are considered to provide useful quantitative data on spatial and temporal changes in vegetation PFC. When compared to the current program of procuring aerial photography, Landsat is more cost effective and easier to analyse with current GIS technology. Landsat capture is also more flexible being flown every 16 days compared to the annual aerial photography. In additional Landsat has a historical dataset dating back to the 1970's which can be used to quantify baseline and historical variability.

To build on the benefits of Landsat monitoring and better support management it is proposed that Landsat focus on target areas where EWR criteria have been established and groundwater or surface water monitoring is occurring. This will allow PFC outputs to be analysed specifically against EWR trigger levels and in-situ groundwater monitoring.

It is therefore recommend that current annual aerial photography be replaced with Landsat capture and analyses to produce a measure of percentage foliage cover (PFC) and a complementary field component to produce a measure of canopy cover (CC) as detailed below.

5. Proposed PFC monitoring

5.1 Establishing PFC baseline

It is expected that vegetation at Millstream will experience natural variability in PFC. In order to determine the range of this natural variability it is proposed that annual PFC analyses be completed to produce a 2005 to 2012 PFC dataset.

This timeframe represents a period of low abstraction and average to high water availability. In addition, as six of the fourteen sites were included in the previous analyses this will result in those sites having a historical dataset from 1979 to current.

The PFC dataset will be used to establish specific scores to define limits of acceptable change, ie;

- PFC limit: to indicate where the magnitude of decline in vegetation condition may be outside natural variability
- Decline limit: to indicate where decline between years is outside natural variability

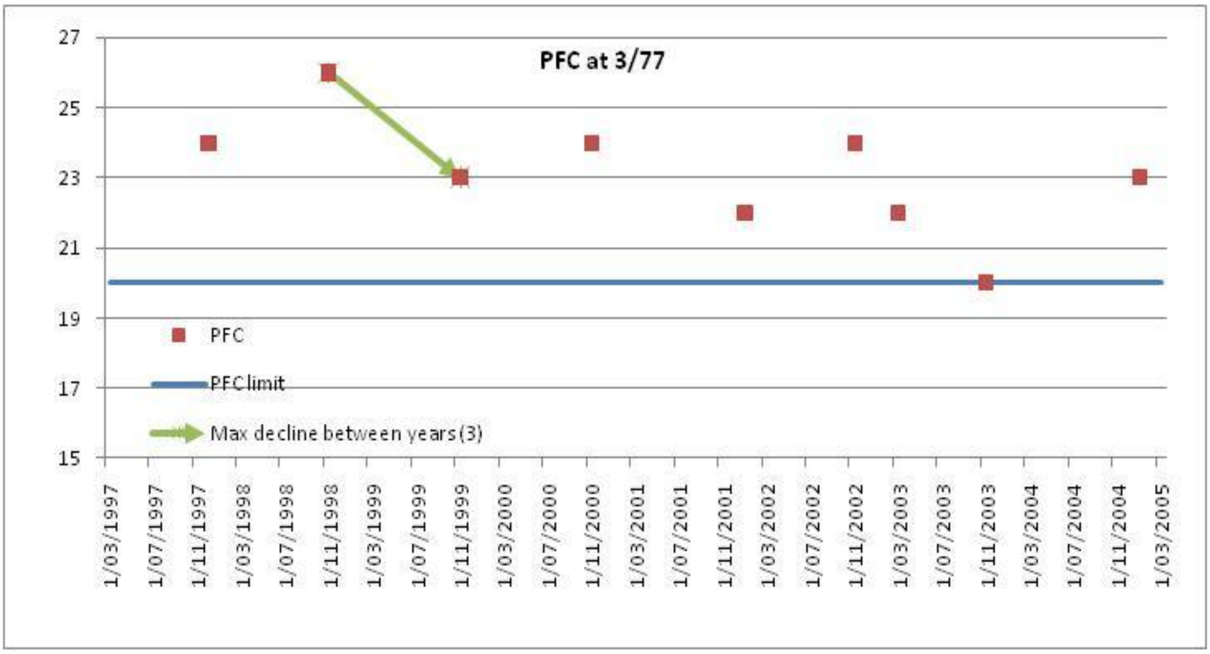


Figure 1 PFC data at bore 3/77 with PFC limit based on historical minimum and decline limit

5.2 PFC analyses

DWaP will procure (funded by the Corporation) and process Landsat imagery annually to produce PFC values for 13 EWR sites (14 bores) and two erosion sites. A difference map for the whole area at 1, 5 and 10 years will also be produced.

DoW will carry out the following review:

- Assess PFC for all sites against PFC limit and Decline limit. If level and trend of change in PFC across the years is within expected limits, write up report for presentation at annual MHCC meeting;

If PFC falls below limits:

- Assess PFC data against in-situ groundwater data and site EWR thresholds.
- Highlight where PFC data shows negative trends beyond those expected and forward to TWG to determine if trends can be explained by other factors (rainfall, erosion, park management activities etc).
- If reason for adverse trend is not found, on-ground monitoring should be conducted the following June if subsequent wet season river flow is less <43,000ML.

5.3 Whole area analyses

Difference maps for the whole area at 1, 5 and 10 year intervals in raster format viewable in ARC map. This product will be used as a general management tool. It will identify areas of change across the whole study area and highlight trends of change at the landscape scale that might otherwise be missed by focusing on site specific areas.

6. On ground canopy cover (CC) monitoring

In conjunction with remote monitoring, an on-ground monitoring component is required to provide additional detail on vegetation condition and provide qualification of other factors that may influence PFC.

On ground monitoring will focus on using digital canopy photography to determine canopy cover (CC) as developed by MacFarlane *et al.* (2007a; 2007b). Temporal change in this count will reflect changes in foliar cover and density and give an indication of whether the trees are water stressed or not. The benefit of using this vegetation monitoring approach over more traditional methods is that it provides objective quantitative data.

This approach involves the establishment of transects within the riparian/wetland vegetation. Along transects, 20 m^2 plots will be established wherever a change in vegetation community type occurs, or at other significant locations (e.g. edge of erosion gully).

Within these plots, canopy photos are taken across the plot to achieve 100% coverage. Sample spacing is typically 10m for vegetation 10-30m tall but may need to be closer for shorter vegetation. Photographs are then processed to differentiate sky pixels from the tree canopy and obtain a pixel count for the canopy cover.

This method is only suited for capturing data on overstorey condition (>6m). To ensure that understory composition is captured a brief vegetation survey will also be done for each plot to record information on:

- vegetation community description
- dominant understorey species
- height & % cover of understorey layers (shrubs, sedges, grasses)
- % bare ground
- fire history
- erosion
- weed invasion
- other disturbances (e.g. access tracks, grazing)
- photo from fixed photo point

Further detail for setting up sites and carrying out canopy photography can be found in the field guide Vegetation monitoring in the Pilbara (DoW, 2013).

Canopy Photography analyses

DoW will design and conduct the initial canopy photography and site survey work whilst training DPaW Rangers on how to carry out the on-ground monitoring. The intent is that DPaW takes responsibility for the field component and DoW undertakes imagery analysis and reporting.

It is anticipated that results from initial canopy photography will be set as an interim canopy cover baseline. This will depend on water availability at the time being above average and no signs of water stress being evident.

7. Monitoring schedule

A total of 13 EWR sites (representing 14 bores) and two erosion sites (without bores) have been selected for the monitoring program (see below table). Details for each site are listed under “Site Description”.

PFC analyses will be undertaken for all sites annually using Landsat imagery in November. It is expected that PFC data will be available the following January.

CC monitoring will be undertaken at five core sites in November each year. These sites have been selected based on their likely response to declining water availability. CC monitoring for remaining sites will occur if required by the trigger and response framework detailed in the operating strategy. Monitoring was carried out at the sites shaded in Table 17 in November 2013 (i.e. 7 out of 13 sites). Monitoring at remaining 6 sites will be progressed in 2014 subject to Corporation funding approval.

Sites **Deep Reach**	PFC	Canopy photography and on-ground monitoring		Bore	EWR site
		Core site	Other site		
Transect along the Northern side of the DR delta	Nov		Nov if Deep Reach Pool ctf declines	NA	
Transect along the southern side of the DR delta	Nov		Nov if Deep Reach Pool ctf declines	NA	
Western edge of pool around EWR site	Nov	Nov		P7/77	√
Eastern edge of pool around EWR site	Nov		Nov if triggered by management framework	P8/77 P7/78	√
Top of pool below road crossing	Nov	Nov		08/04	√
Upstream of Chinderwarriner Pool	Nov	Nov		1E	√
Delta					
East of Delta Hill	Nov		Nov if triggered by management framework	03/04	√
West of Delta Hill upstream site	Nov	Nov		04/04	√
Bore 4/78	Nov		Nov if triggered by management framework	P4/78	√
Bore 3/77	Nov		Nov if triggered by management framework	P3/77	√
Bore 12/04	Nov	Nov		12/04	√
Woodley	Nov	Nov		P2/77	√
Downstream					
Palm Pool – northern bank	Nov	Nov		P10	√
Palm Creek					
Palm Creek – down-creek spring fed	Nov		Nov if triggered by management framework	P2	√
Palm Creek – up-creek on aquifer	Nov		Nov if triggered by management framework	P8	√
Whole area	Nov				

Table 17 Proposed vegetation monitoring schedule for Millstream

8. Proposed budget and responsibilities for annual monitoring

The estimated cost of setting up the monitoring program and ongoing cost are detailed below. The budget will need annual review and agreement from the Corporation.

Budget for initial setup and ongoing monitoring of Millstream vegetation monitoring

Initial set-up costs to be covered by Water Corporation	Sub Total	Total
DPaW - Processing and Miscellaneous Costs		
Initial pre-processing of Landsat imagery (outsourced)	$1,000	
Travel, car hire, accommodation, meals (2 people, 2 days, Perth to Millstream)	$2,500	
Calibration of ground data to imagery, to produce PFC data and trends for years 2005-2012	$1,500	
DoW - Site setup, canopy photography and training DEC staff		
Travel, car hire, meals (2 people, 5 days, Perth to Millstream) - accommodation at WC depot	$2,950	
Initial setup 2013		**$7,950**

Ongoing annual costs to be covered by Water Corporation	Sub Total	Total
DPaW - Ongoing annual monitoring costs	$2,000	
This is based on:		
1. The continued ability to access free Landsat imagery,		
2. Pre-processing of the imagery to national standards,		
3. Developed method (2013) being applied to future imagery, and		
4. Production of updates in formats suitable to DPaW and DoW.		
DoW - Ongoing annual monitoring costs	$0	
Ongoing costs from 2014		**$2,000**

Initial set-up in-kind support
DPaW - project specific equipment and staff training
Perth staff (2 people, 2 days)
Regional staff (2 people, 4 days)
GPS and satellite phone
Camera
Field hardware (computing etc)
Software
DoW - project specific equipment, site setup and training of DEC staff
Perth staff (2 people x 5 days)
Consumables and field equipment
Ongoing annual in-kind support
DPaW
Validation using core sites (2 field staff x 2 days) and 2nd iteration of processing (if required) (2 field staff x 3 days).
DoW
Data processing of canopy photography and reporting (1 person x 2 days) plus additional sites as required

Site description

Site details are as follows:

1. Delta bores P4/78 and P3/77
    - representative of hydrological conditions immediately downstream of the delta
    - vegetation communities 5, 6 and 7
    - existing vegetation transect G, last monitored in 2008
    - both bores with good long term datasets and recent logger data (2009-current)
    - depth to groundwater

2. Delta bore 12/04
    - representative of high water availability on eastern side of delta
    - mixed vegetation communities, but includes area of *M. argentea* over sedges.
    - transect to be established
    - 2004 bore with logger data (2009- current)

3. Deep Reach bore P7/77
    - representative of hydro conditions on eastern side of DR which may be impacted by erosion gullies in future
    - vegetation community 1 (LA/EC woodland over acacia)
    - existing vegetation transect E last monitored in 1994
    - older bore with patchy data, logger installed May 2011

4. Deep Reach bore 8/04
    - representative of hydro conditions at top of DR
    - vegetation community 10 (LA/ EC forest)
    - existing veg transect H downstream, last monitored in 1994
    - 2004 bore, logger installed May 2011

5. Deep Reach Toe (northern transect)
    - northern side of Deep Reach delta currently feed by outflow channel
    - erosion channels
    - vegetation community 2 (EC/MA woodland)
    - no transect – annual erosion survey
    - no bore

6. Deep Reach Toe (southern transect)
    - southern side of Deep Reach delta aligning erosion channels
    - erosion channels
    - vegetation community 2 (EC/MA woodland)
    - no transect – annual erosion survey
    - no bore

7. Palm Pool, P10
    - representative of hydro conditions downstream of delta
    - vegetation community 1 (LA/ EC woodland)
    - existing vegetation transect A, last monitored 2008
    - 2 shallow bores not currently monitored, loggers installed May 2011

8. Woodley Delta, bore P2/77
    - representative of previous vegetation impacts
    - vegetation communities 5 and 7
    - existing transect C, last monitored in 1994
    - groundwater data since 1979

9. Deep Reach, bore P8/77, P7/78
    - representative of hydro conditions on the western side of Deep Reach Pool
    - vegetation communities; Open woodland of E. *Camaldulensis* over mixed shrubs of Cynodon *dactylon*
    - existing vegetation transect F, last monitored 2008
    - groundwater data since 1978, loggers installed 2009

10. Delta, east of Delta Hill, bore 3/04
    - representative of hydro conditions on the eastern side of the delta aligning channel 1
    - vegetation community 1 (LA/ EC woodland)
    - no transect
    - groundwater data since 2004, no logger

11. Delta, west of Delta Hill, bore 4/04
    - representative of hydro conditions on the western side of the delta aligning channel 3/4/5/6
    - forest E. *camaldulensis* and L *alfredii* and M. *argentea* and E. *camaldulensis* over M. bracteata over sedges
    - no transect
    - 2004 bore, logger installed May 2011

12. Palm Creek, upstream, bore P8
    - representative of hydro conditions along Palm Creek where situated on aquifer
    - veg community of L. Alfredii
    - no transect
    - groundwater data since 1976

13. Palm Creek, downstream, bore P2
    - representative of hydro conditions along Palm Creek where situated off aquifer
    - veg community of L. Alfredii
    - no transect
    - groundwater data since 1976

APPENDIX E – Advanced Water Monitoring Summary Template

Heading	Advanced WMS
Section 1: General Scheme Information	
1. Introduction	
1.1 Period of Statement • Includes table of current licences	•
1.2 Licence and WRMOS Update • This section is only included where there have been changes to the licences and/or WRMOS since the last annual summary	•
1.3 Climate • Monthly maximum and minimum temperature over the water year for Millstream Station 5012	•
1.4 Rainfall • Brief general description of rainfall at Millstream Station 5012 and Water Corporation Harding Dam Rainfall station • Tabular presentation of monthly rainfall for the water year • Graphical display of monthly rainfall for the water year	•
2. Abstraction	
2.1 Scheme conjunctive use • Brief discussion on conjunctive use	•
2.2 Scheme annual abstraction • Brief discussion on abstraction over the water year • Tabular presentation of annual abstraction compared against previous water year • Graphical presentation of monthly abstraction	•
2.3 Details of abstraction, consumption , unit and water efficiency • Water losses as a percentage • Average use per unit • Comparisons with efficiency targets • Water efficiency measures implemented over review period • Any efficiency improvement plans	•
Section 2 – Harding Dam	
• Statement of compliance in tabular format	•
• Details of meter changes which occurred over water year	•
• Statement of compliance - Asset operated in accordance with WRMOS - Asset monitored in accordance with expectations - Asset performance; general description of trends observed in water levels and storage volume o inclusion of graphical presentation of; - Harding Dam storage level - Harding Dam storage volume - Waranoolar pool water level - Pinanular Pool water level - Discussion for Bore 5/81 water levels against trigger of 32.5 mAHD - Asset performance; general description of trends observed in water quality o Inclusion of tabular presentation of major component analysis - Asset performance; general description of trends observed in abstraction in comparison to previous year o Inclusion of tabular presentation of monthly abstraction - Any additional commentary	•

Heading	Advanced WMS
Section 3 - Millstream	
• Statement of compliance in tabular format	•
• Details of meter changes which occurred over water year	•
• Statement of compliance - Asset operated in accordance with WRMOS - Asset monitored in accordance with expectations - Asset performance; general description of trends observed in water levels and streamflow o inclusion of tabular presentation of; - variation in MAL o inclusion of graphical presentation of; - MAL water levels vs annual rainfall - Chinderwarriner Pool annualised outflow - Chinderwarriner Pool instantaneous outflow - Crossing Pool annualised outflow - Crossing Pool instantaneous outflow - Asset performance; general description of trends observed in water quality o Inclusion of tabular presentation of major component analysis for production bores - Asset performance; general description of trends observed in abstraction in comparison to previous year o Inclusion of tabular presentation of monthly abstraction o Inclusion of graphical presentation of Millstream borefield abstraction for the past five years - Any additional commentary	•
Section 4 – Scheme recommendations	
• Scheme recommendations	•
APPENDIX A – Raw Data	
Raw Data is to be provided to DoW electrically in an excel spreadsheet and is to be provide on a CD with submittal of the hard copy annual statement. Data to be included is as follows;	•
• *Flow data for;	•
o Woodley Creek	•
o Peters Creek	•
o Palm Creek	•
o Deep Reach Pool	•
o Chinderwarriner Pool	•
• #Salinity data for;	•
o Harding Dam	•
o All Millstream Production Bores	•
o Deep Reach and Chinderwarriner monitoring bores	•
o Deep Reach Pool	•
o Chinderwarriner Pool	•
• ^Water level data for;	•
o Pinanular and Waranoolar Pools (derived from monitoring bores 1/00, 2/00 and 3/00)	•
o Harding Dam monitoring bores (DSE1/81, DSE2/81, DSE3/81, DSE4/81, DSE5/81 and DSE6/81)	•
o All Millstream Production Bores	•
o Deep Reach and Chinderwarriner monitoring bores	•
o Millstream unequipped production bores (PB9, PB10, PB11, and PB12)	•
o MAL8 monitoring bores and bore 7A	•

Heading	Advanced WMS
○ Millstream monitoring bores P2/77, P3/77, P4/78, 03/04, 12/04, 04/04, P2, P8, P8/77, P7/78, 08/04, P10, P7/77, P9A/78	•

*Flow data is to be presented as flow rate
#Salinity data is to be presented as Conductivity mS/m and TDS mg/L
^Water level data to be presented as mAHD

APPENDIX F – Template for Reporting to Bi-Monthly TWG Meeting

Recharge class	

Monitoring site	(A) Annual trigger	(B) Annual Criteria	(C) Most recent reading	(D) Reading date	(E) Trigg Criteria breached
Groundwater level			mAHD		
MAL 8					
Millstream Bore Nwws P2					
Millstream Bore Nwws P8/77					
Millstream Bore Nwws P2/77					
Millstream Bore Nwws P3/77					
Millstream Bore Nwws P4/78					
Millstream Bore Nwws P7/78					
Millstream Bore Nwws P7/77					
Millstream Bore Nwws P10					
Millstream Bore 3/04					
Millstream Bore 4/04					
Millstream Bore 8/04					
Millstream Bore 12/04					
Outflow			**L/Sec**		
Chinderwarriner flow					
Crossing Pool					
Production			**ML**		
Millstream cumulative annual					
Harding Cumulative annual					
Storage level Harding Dam			**mAHD**		
Storage level					

APPENDIX G – Template for raw monitoring data to be supplied bi-monthly to DoW in excel format within 2 weeks of monitoring data

Site/Monitoring Point	Reading Date	mAHD rested
Millstream Bore Nwws P2		
Millstream Bore Nwws P8		
Millstream Bore Nwws 1E		
Millstream Bore Nwws 1C		
Millstream Bore Nwws 7A		
Millstream Bore Nwws 7C		
Millstream Bore Nwws 2B		
Millstream Bore Nwws 2C		
Millstream Bore Nwws 4A		
Millstream Bore Nwws 8C		
Millstream Bore Nwws 5B		
Millstream Bore Nwws P8/77		
Millstream Bore Nwws P9A/78		
Millstream Bore Nwws P2/77		
Millstream Bore Nwws P3/77		
Millstream Bore Nwws P4/78		
Millstream Bore Nwws P7/78		
Millstream Bore Nwws P7/77		
Millstream Bore Nwws P10		
Millstream Bore 3/04		
Millstream Bore 4/04		
Millstream Bore 8/04		
Millstream Bore 12/04		
Salinity	**Reading Date**	**TDS**
Deep Reach Pool		
Chinderwarriner Pool		
Outflow	**Reading Date**	**L/Sec**
Chinderwarriner flow		
Crossing Pool		
Woodley Creek		
Palm Creek		
Peters Creek		
Millstream		
Production	**Date reading to**	**ML**
Cumulative annual		
Harding Dam		
Production	**Date reading to**	**ML**
Cumulative annual		
Storage level Harding Dam	**Date of reading**	**mAHD**
Storage level		

Appendix C: Review of the YAC Referral

General Assessment of the YAC (2024) referral

Aspect	YAC Comments	Water Corporation Responses
Groundwater abstraction volumes comprising the proposal.	The YAC referral states the proposal comprising 9GL/a until at least 2032.	The proposal is to abstract a total of 6 gigalitres per annum (GL/a) until 2032, with an additional contingency of 3GL/a to 2027.
Landforms as a key environmental factor.	The YAC referral document outlines Landforms as a key environmental factor with the key environmental value of this factor being the Millstream Wetland system comprising the Fortescue River and tributaries, the Millstream pools (Deep Reach, Crossing, Livistona and Palm pools) and associated riparian and wetland vegetation.	Water Corporation does not consider Landforms as a key environmental factor for assessment of the proposal, as the EIA for the Millstream Wetland system and Millstream pools are assessed under the Inland Waters and Social Surroundings key environmental factor and riparian and wetland vegetation assessed under the Flora and Vegetation, Terrestrial Fauna and Social Surroundings key environmental factors. The EPA (2018) Environmental Factor Guideline: Landforms, outlines the definition of landforms, and how the landforms factor link with other environmental factors for the purposes of environmental impact assessment under Part IV of the EP Act. EPA defines landforms as: The distinctive, recognisable physical features of the earth's surface having a characteristic shape produced by natural processes. A landform is defined by the combination of its geology (composition) and morphology (form). The Guidelines lists examples of landforms, as banded iron formations, mesas, dunes and dune fields, caves and cave systems. Wetlands, pool and vegetation are not considered within the scope of the EPA key environmental factor for Landforms as they do not fit the examples provided and are not features that are intended to be assessed under this key environmental factor. The addition of Landforms as a key environmental factor is not appropriate for wetlands, pools and riparian and wetland vegetation and an EIA on these environmental values will be undertaken under the Inland Waters, Flora and Vegetation, Terrestrial Fauna and Social Surroundings key environmental factors.
Rights in Water and Irrigation Act	The YAC proposal requested an assessment of the proposal under Part IV of the EP Act, due to the Rights in Water	The Department of Water (now DWER) undertakes technically robust and scientific assessments of all impacts from groundwater abstraction as part of its core

Aspect	YAC Comments	Water Corporation Responses
1914 (WA) (RiWI Act) as an assessment pathway for the proposal	and Irrigation Act 1914 (WA) (RiWI Act) not mandating a comprehensive evaluation of cumulative impacts when granting multiple groundwater extraction licences for a single aquifer, nor does it require robust public or stakeholder engagement.	accountability for the management of the State's groundwater aquifers assets and issues groundwater licences based on the outcomes of these assessments. The allocation planning documents considers the cumulative impacts of the aquifer and sets allocation limits for the aquifer resource. These cumulative impact assessment documents for the Pilbara include: • Lower Fortescue groundwater allocation limit report. Method used to set an allocation limit and licensing rules for the Lower Fortescue alluvial aquifer. Water resource allocation and planning series Report no. 49 (Department of Water, January, 2011). • Braimbridge, M, Antao, M and Loomes, R, 2010, Groundwater dependent ecosystems for Millstream: ecological values and issues, Environmental water report series, Report no. 13 (Department of Water, 2010). • Braimbridge, M 2010, Millstream aquifer – determination of a long-term sustainable yield and long-term reliable allocation, Allocation planning series, report no. 42 (Department of Water, 2010). • Pilbara Groundwater Allocation Plan 2013. Water resource allocation and planning report series Report no 55 (Department of Water, 2013). • Antao, M. 2013, Pilbara monitoring program to support the Pilbara groundwater allocation plan/. Water resource allocation and planning report series October 2013 (Department of Water, 2013). • Department of Water 2010, Pilbara regional water plan 2010–2030 (Department of Water, 2010). • Pilbara regional water supply strategy. A long-term outlook of water demand and supply. Report no. 1. Regional water supply strategy series (Department of Water, 2013). All these documents are publicly available. Stakeholder engagement on the water allocation in the Pilbara is undertaken in the Millstream Technical Working Group. YAC is a member of this working group. The Corporation considers the RiWI Act as a suitable assessment pathway for the proposal given that the DoW (now DWER) are the authority for allocation planning,

Aspect	YAC Comments	Water Corporation Responses
		this application planning is scientifically robust, all allocation planning and strategy documents are publicly available and further community engagement is undertaken in the Millstream Technical Working Group, which YAC is a member. The Corporation considers that the RiWI Act can mitigate the potential impacts of the proposal on the environment including the assessment of cumulative impacts and public or stakeholder engagement. The decision-making process for the grant of a section 5C licence renewal under the RiWI Act provides a comprehensive framework for considering all of the potential impacts that are raised in the YAC referral and relevant to an EPA Part IV assessment, including both environmental and Aboriginal heritage impacts. When considering an application for renewal of a section 5C licence, the Minister has broad discretion to consider anything that is relevant under clauses 7 and 22 of Schedule 2 of the RiWI Act. There are no relevant restrictions, geographically, in terms of impacts or generally. The assessment of impacts from the proposal can therefore be included under clauses 7 and 22 of Schedule 2 of the RiWI Act, via issuing of a 5C licence. Whilst the EPA's factor objectives are not expressly referred to in the RiWI Act or guidance, all of the objectives mentioned in the referral (for flora and vegetation, subterranean fauna, landforms, terrestrial fauna, inland waters and social surroundings) can and must be taken into account in the section 5C decision-making process, to the extent that the factors are: • part of the Millstream aquifer ecosystem and environment. • potentially impacted by the ecologically unsustainable use of the aquifer. • a matter of public (including social) interest; and/or • considered by the Minister to be relevant. The YAC referral concerns the potential impacts arising from the proposed abstraction, in particular matters like declining ground and surface water levels, seasonal availability of water, erosion, salinity, water temperature changes and water quality, and the implications those direct impacts could have on flora, stygofauna, terrestrial fauna, inland waters, landforms and Aboriginal cultural heritage values in the area. All of these potential impacts can be considered as part of a section 5C licence renewal decision-making process.

Aspect	YAC Comments	Water Corporation Responses
		As part of the 5C licence decision-making processes, in accordance with Part III, section 4 of the RiWI Act, the Minister must: (a) provide for the management of water resources, and in particular (i) sustainable use and development to meet the needs of current and future users; and (ii) protection of their ecosystems and the environment in which water resources are situated, including by the regulation of activities detrimental to them; and (b) promote the orderly, equitable and efficient use of water resources. (c) foster consultation with members of local communities in the local administration, and to enable them to participate in that administration; and (d) assist the integration of the management of water resources with the management of other natural resources. The assessment and decision-making process for a 5C licence must consider Part III, section 4 of the RiWI Act, and therefore meets the requirements for other statutory decision-making processes "that can mitigate the potential impacts of the proposal on the environment" stated under s38G(4) of the EP Act. Licensing decisions relating to the Millstream aquifer will also be guided by the Pilbara Groundwater Allocation Plan (October 2013). The assessment of cumulative impacts is an inherent part of the RiWI Act licensing framework by virtue of the fact that the Act is, a water allocation regime. The framework for section 5C licences under the RiWI Act (including the renewal application process and ongoing consultation/engagement, management, monitoring and reporting obligations) allows for the assessment, protection and management of all of the environmental factor objectives including: • protect flora and vegetation so that biological diversity and ecological integrity are maintained.

Aspect	YAC Comments	Water Corporation Responses
		• protect subterranean fauna so that biological diversity and ecological integrity are maintained. • protect terrestrial fauna so that biological diversity and ecological integrity are maintained. • maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected; and • to protect social surroundings from significant harm.
The use of the Aboriginal Heritage Act 1972 to protect Aboriginal cultural values.	Aboriginal Heritage Act 1972 (WA) (AH Act) does not offer sufficient protection for the Aboriginal cultural values at Millstream, particularly the intangible cultural and spiritual connections between Aboriginal people of the Pilbara, including the Yindjibarndi People, and the Millstream area.	Refer to Section 6.2 The Corporation considers that the RiWI Act provides sufficient protection for the Aboriginal cultural values at Millstream, particularly the intangible cultural and spiritual connections between Aboriginal people of the Pilbara, including the Yindjibarndi People, and the Millstream area. The decision-making process for the grant of a section 5C licence renewal under the RiWI Act provides a comprehensive framework for considering all of the potential impacts that are raised in the YAC referral and relevant to an EPA Part IV assessment, including both environmental and Aboriginal heritage impacts. When considering an application for renewal of a section 5C licence, the Minister has a broad discretion to consider anything that is relevant under clauses 7 and 22 of Schedule 2 of the RiWI Act. There are no relevant restrictions, geographically, in terms of impacts or generally. The assessment of impacts from the proposal can therefore be included under clauses 7 and 22 of Schedule 2 of the RiWI Act, via issuing of a 5C licence. Whilst the EPA's factor objectives are not expressly referred to in the RiWI Act or guidance, all of the objectives mentioned in the referral (including social surroundings) can and must be taken into account in the section 5C decision-making process, to the extent that the factors are: • part of the Millstream aquifer ecosystem and environment. • potentially impacted by the ecologically unsustainable use of the aquifer. • a matter of public (including social) interest; and/or

Aspect	YAC Comments	Water Corporation Responses
		• considered by the Minister to be relevant. As part of the 5C licence decision-making processes, in accordance with Part III, section 4 of the RiWI Act, the Minister must: (a) provide for the management of water resources, and in particular (i) sustainable use and development to meet the needs of current and future users; and (ii) protection of their ecosystems and the environment in which water resources are situated, including by the regulation of activities detrimental to them; and (b) promote the orderly, equitable and efficient use of water resources. (c) foster consultation with members of local communities in the local administration, and to enable them to participate in that administration; and (d) assist the integration of the management of water resources with the management of other natural resources. The assessment and decision-making process for a 5C licence must consider Part III, section 4 of the RiWI Act, and therefore meets the requirements for other statutory decision-making processes "that can mitigate the potential impacts of the proposal on the environment" stated under s38G(4) of the EP Act. The framework for section 5C licences under the RiWI Act (including the renewal application process and ongoing consultation/engagement, management, monitoring and reporting obligations) allows for the assessment, protection and management of all of the environmental factor objectives including: to protect social surroundings from significant harm.
Proposal requiring public engagement	A greater level of public engagement is required, which can be achieved via the EPA assessment process.	The MHCC and TWG were established to jointly manage the WPWSS sources to ensure that water dependant values are protected. As noted above, both MHCC and the TWG include representatives from the Corporation, DWER, DBCA and YAC.

Aspect	YAC Comments	Water Corporation Responses
		MHCC meets annually and was established to provide strategic advice to DWER on management issues associated with Harding Dam and Millstream Borefield. The DWER Regional Manager chairs the meeting, and the DWER is responsible for organising the meeting and taking and distributing minutes. A subgroup of the MHCC, the TWG comprises of operational and regional staff. TWG members are involved in the day-to-day operation, monitoring and management of Harding Dam and Millstream Borefield. The TWG meeting occurs quarterly, reporting to MHCC, as required in the WRMOS. Chairmanship moves between DWER and the Corporation every year (the Corporation took on chairmanship following the July 2024 MHCC meeting). Attendees are representatives from the Corporation, DWER, DBCA and YAC. YAC has been represented by employees of Yindjibarndi Water, Right Water Co. and RFF Australia. Representatives of the Ngarluma people are also invited but have not attended. Monthly meetings with representatives from the Corporation, YAC and DWER were also established in December 2024 due to heightened interest in the performance of Millstream, Harding Dam and the WPWSS. It was agreed there would be a benefit in meeting regularly to discuss issues and advise of progress on actions. YAC is represented by employees of Yindjibarndi Water and Right Water Co. Outside the MHCC and TWG, the Corporation engages with DBCA and YAC on project related matters in the Millstream area. In addition, the Corporation has engaged DWER Water regarding the RiWI Act licence renewals.
Requirement for an EIA on the Millstream Wetland system.	Only an assessment under the EP Act can ensure that both environmental and cultural heritage risks are comprehensively evaluated.	The environmental and cultural heritage risks from the proposal to abstract groundwater from the Millstream aquifer has previously been subject to an EIA via the sustainable yield studies (DoW, 2010) and the Pilbara Groundwater Allocation Plan (2013) by the (DoW) (now DWER) as part of its core accountability for the management of the State's groundwater aquifers assets and issuing groundwater licences based on the outcomes of these assessments. The EIA undertaken has been comprehensive, scientifically robust and meets the requirements for the EPA

Aspect	YAC Comments	Water Corporation Responses
		to determine whether the proposal may have a significant effect on the environment. The management of environmental and cultural heritage risks from the proposal to abstract groundwater from the Millstream aquifer will continue to be undertaken in accordance with the WRMOS (Appendix B) which is a co-authored document with DWER and has been developed using robust, scientific techniques and is regulated under the RiWI Act. The environmental trigger values, monitoring requirements and management measures in the WRMOS are based on the EIA undertaken by DoW as part of the Pilbara allocation planning. The Corporation considers that the RiWI Act can be the primary instrument for assessment and management of environmental and cultural heritage risks. The decision-making process for the grant of a section 5C licence renewal under the RiWI Act provides a comprehensive framework for considering all of the potential impacts that are raised in the YAC referral and relevant to an EPA Part IV assessment, including both environmental and Aboriginal heritage impacts. When considering an application for renewal of a section 5C licence, the Minister has broad discretion to consider anything that is relevant under clauses 7 and 22 of Schedule 2 of the RiWI Act. There are no relevant restrictions, geographically, in terms of impacts or generally. The assessment of impacts from the proposal can therefore be included under clauses 7 and 22 of Schedule 2 of the RiWI Act, via issuing of a 5C licence. Whilst the EPA's factor objectives are not expressly referred to in the RiWI Act or guidance, all of the objectives mentioned in the referral (for flora and vegetation, subterranean fauna, landforms, terrestrial fauna, inland waters and social surroundings) can and must be taken into account in the section 5C decision-making process, to the extent that the factors are: • part of the Millstream aquifer ecosystem and environment. • potentially impacted by the ecologically unsustainable use of the aquifer. • a matter of public (including social) interest; and/or • considered by the Minister to be relevant.

Aspect	YAC Comments	Water Corporation Responses
		The YAC referral concerns the potential impacts arising from the proposed abstraction, in particular matters like declining ground and surface water levels, seasonal availability of water, erosion, salinity, water temperature changes and water quality, and the implications those direct impacts could have on flora, stygofauna, terrestrial fauna, inland waters, landforms and Aboriginal cultural heritage values in the area. All of these potential impacts can be considered as part of a section 5C licence renewal decision-making process. As part of the 5C licence decision-making processes, in accordance with Part III, section 4 of the RiWI Act, the Minister must: (a) provide for the management of water resources, and in particular (i) sustainable use and development to meet the needs of current and future users; and (ii) protection of their ecosystems and the environment in which water resources are situated, including by the regulation of activities detrimental to them; and (b) promote the orderly, equitable and efficient use of water resources. (c) foster consultation with members of local communities in the local administration, and to enable them to participate in that administration; and (d) assist the integration of the management of water resources with the management of other natural resources. The assessment and decision-making process for a 5C licence must consider Part III, section 4 of the RiWI Act, and therefore meets the requirements for other statutory decision-making processes "that can mitigate the potential impacts of the proposal on the environment" stated under s38G(4) of the EP Act. Licensing decisions relating to the Millstream aquifer will also be guided by the Pilbara Groundwater Allocation Plan (2013). Assessment of cumulative impacts is an inherent part of the RiWI Act licensing framework by virtue of the fact that the Act is, at its heart, a water allocation regime. The framework for section 5C licences

Aspect	YAC Comments	Water Corporation Responses
		under the RiWI Act (including the renewal application process and ongoing consultation/engagement, management, monitoring and reporting obligations) allows for the assessment, protection and management of all of the environmental factor objectives including: • protect flora and vegetation so that biological diversity and ecological integrity are maintained. • protect subterranean fauna so that biological diversity and ecological integrity are maintained. • protect terrestrial fauna so that biological diversity and ecological integrity are maintained. • maintain the hydrological regimes and quality of groundwater and surface water so that environmental values are protected; and • to protect social surroundings from significant harm.
Alternative water supply options	The YAC referral states "other options which may support an alternative solution, which YAC has repeatedly conveyed to DWER and the the Corporation".	**Seawater Desalination Plant (SDP)**: The Corporation is investigating a SDP as the preferred solution to supplement the current water sources. Potential locations are being explored, with engagement ongoing to confirm possible plant locations. **Interim Supply from RTIO's Dampier SDP**: The State Government announced that the Corporation would engage with RTIO on the feasibility of using Stage 2 of RTIO's Dampier SDP for an interim supply of 4GL/a until a long-term additional source can be delivered. The forecast delivery date for Stage 2 is 2027. **Harding Water Treatment Plant Upgrades**: A suite of upgrade works at the Harding water treatment plant and in the distribution system is planned to maximize the use of Harding Dam and reduce abstraction from Millstream Borefield. **Demand Management Activities**: Ongoing demand management activities include the Waterwise Towns program, which aims to improve water efficiency in the West Pilbara region. **Independent Reassessment of Aquifer Sustainable Yield**: The Corporation has commenced planning for an independent reassessment of the aquifer's sustainable

Aspect	YAC Comments	Water Corporation Responses
		yield, with a plan for the scope to be developed in collaboration with DWER and YAC.
Historical groundwater abstraction volumes	The existing abstraction rates, over the last 25 years have exceeded 6GL/a three times. The last record rate of abstraction of 9GL/a or more was 1983.	Groundwater abstraction has exceeded 6GL/a during 1972-1985, 1988, 2000-2003, 2012, 2014-2016. Groundwater abstraction exceeded 9GL/a 1981-1985, 2001-2004 and 2012. The observations and monitoring made during these periods of comparable abstraction volumes have been used to assess impacts of the proposal.
Matters of National Environmental Significance	The YAC referral lists potential impacts that proposal has on Matters of National Environmental Significance including: - Impacts to the Millstream-Chichester National Park as a place listed on the Federal Government National Estate. - Impacts to the Millstream pools; listed on the Directory of Important Wetlands and previously nominated for RAMSAR status. - Impacts on an identified abundant and diverse population of stygofauna, with the aquifer previously being identified as having the richest aquifer in the Pilbara region, with 16 species (Eberhard et al. 2005). The stygofauna communities of the freshwater aquifers within the Millstream Chichester National Park are a Threatened Ecological Community for the purposes of the EPBC Act, despite not yet being listed.	A Protected Matters Search Tool (PMST) has been undertaken to identify MNES that may be potentially impacted by the proposal. The listed MNES that are known or likely to occur include: <u>List threatened species</u> • Northern Quoll, Digul [Gogo-Yimidir], Wijingadda [Dambimangari], Wiminji [Martu] • Grey Falcon • Pilbara Olive Python • Pilbara Leaf-nosed Bat • Ghost Bat <u>Migratory species</u> • Common Sandpiper • Fork-tailed Swift The Chichester National Park, the Millstream pools, Millstream Wetlands, stygofauna species and stygofauna communities of the freshwater aquifers within the Millstream Chichester National Park are not listed as MNES. The Millstream Wetlands are not listed as RAMSAR status.

Aspect	YAC Comments	Water Corporation Responses
Erosion and geotechnical stability	The Millstream pools are already susceptible to erosion through natural processes, however additional pressures associated with historical pastoral activities and water abstraction can further exacerbate erosion outcomes. Deep Reach pool is particularly susceptible to erosion and has been subject to ongoing erosion management measures implemented and monitored through the Millstream Technical Working Group (Brougham 2015). Proposed increased abstraction beyond sustainable limits could further contribute to the permanent change in the landforms of the Millstream Wetlands by enabling further erosion without adequate investment in preventative and management options. Detailed analysis of the geotechnical stability of the landforms and the potential for increased erosion risk from a reducing watertable and water levels has not been completed. This analysis is critical to determine whether additional mitigation and management measures are needed to maintain the integrity of the Millstream pools and tributaries distinctive landforms.	YAC (2024) discussed the impacts from erosion on the Millstream Wetlands, including the pools. In response to the ongoing focus on erosion by the MHCC and TWG, the Corporation commissioned a fluvial geomorphology study for the section between Deep Reach and Crossing pools (4DGeotechnics, 2024). The development of erosion channels between the various pools (downstream of Deep Reach, Crossing and Chinderwarriner pools), forming relatively steep stream bed intervals, that continue to erode upstream, have been an ongoing issue since the mid-1960s. The erosion occurs in stages, commencing with sheetwash, initial channel development and entrenched upper channels within the alluvium soils until channels form where calcrete (Millstream aquifer) is exposed at the base of the channels. The cause of channel development and erosion at the overflow point at Deep Reach pool is due to erosion of the alluvial soils. The underlying Millstream aquifer calcrete and Marra Mamba formation are less permeable, causing the runoff to erode the softer alluvium, resulting in exposure of the underlying watertable (Figure 27). This is considered a natural process, exacerbated by fire and hydroclimatic conditions and not attributed to the proposal. Increased abstraction is not likely to result in further erosion, as it is rain-runoff that the direct observed cause of erosion, the erosion being observed where at the boundary of the alluvium the underlying Millstream calcrete or Marra Mamba formations. A geotechnical assessment is an analysis tool that is used to predict the maximum load that can be supported by a geostructure without inducing failure. A geotechnical stability assessment of surface pools is not considered appropriate. A geomorphology assessment may be considered more appropriate and this work is in progress.
Stygofauna	The likely reduction in groundwater levels resulting from excessive abstraction above recognised sustainable limits could lead a direct and potentially significant	The assessment of environmental impacts of the Millstream, including an assessment on stygofauna was undertaken by DoW and reported in the following documents:

Aspect	YAC Comments	Water Corporation Responses
	impacts on the vulnerable stygofauna communities within the Millstream aquifer.	• Braimbridge, M, Antao, M and Loomes, R, 2010, Groundwater dependent ecosystems for Millstream: ecological values and issues, Environmental water report series, Report no. 13 (Department of Water, 2010). • Braimbridge, M 2010, Millstream aquifer – determination of a long-term sustainable yield and long-term reliable allocation, Allocation planning series, report no. 42 (Department of Water, 2010). • Braimbridge et al., 2010[1], outlined the following stygofauna assessments were undertaken: • Reeves, JM, De Deckker, P & Halse, SA 2007, 'Groundwater ostracods from the arid Pilbara region of northwestern Australia: distribution and water chemistry', Hydrobiologia, 585, 99-118. • Eberhard, SM, Halse, SA & Humphreys, WF 2005, 'Stygofauna in the Pilbara region, north-west Western Australia: a review', Journal of the Royal Society of Western Australia, 88, 167-176. It was determined that the impacts to stygofauna were acceptable based on the allocation limits presented in the above reports. The EPA Environmental Factor Guideline: Subterranean Fauna (EPA, 2016) uses available habitat and habitat connectivity to assess the potential for species decline. The abstraction of groundwater by the Corporation does not deplete the aquifer and suitable habitat remains to allow for continued survival of stygofauna species. Implementation of the proposal may result in a 5% change to subterranean fauna habitat. Since 2014 a maximum allowed reduction of habitat was set by DWER as a condition of the Corporation's licence to abstract, the criteria represent a less than 5% allowable reduction in habitat. A 5% change in watertable is not considered a significant impact given there is extensive fauna habitat remaining; 950 km^2 range extent and around 30m of saturated thickness remaining. This is not considered a significant impact to subterranean fauna, due to the maximum allowable change representing less than 5% of the available habitat and the ability for subterranean fauna to migrate to lower in the aquifer. The proposal is not likely to have a

[1] Braimbridge, M, Antao, M and Loomes, R, 2010, Groundwater dependent ecosystems for Millstream: ecological values and issues, Environmental water report series, Report no. 13 (Department of Water, 2010).

Aspect	YAC Comments	Water Corporation Responses
		significant impact on subterranean fauna due to the availability of substantial suitable habitat remaining.
Sustainable abstraction level of 4GL/a	The Study does not include climatic inputs into the conceptual understanding of the Millstream aquifer system.	The Study delivers a recommended future abstraction limit of 4 GL/yr. The report, and appendices do not describe specifically how this number was calculated. Therefore, a review of the methodology to calculate the specific recommended abstraction volume is not possible. The Yindjibarndi Water Study methodology and analysis is not consistent with the current conceptual understanding of the Millstream aquifer system. The study does not recognise the fundamental nature of surface water recharge as a primary system input despite some citations and discrete elements of the study recognising this. Yindjibarndi Water Study indicates that abstraction is fundamentally driving water level decline and that reducing abstraction can compensate for declines. Determination of a long-term sustainable yield and long-term reliable allocation, recommended a long-term reliable allocation of 6GL (DoW, 2010). The study recognises the variable nature of water within the system due to the influence of direct rainfall and surface water recharge and allows for discharge to the river pools at a level that will ensure the ongoing survival of the ecosystems.
EIA of the proposal	The proponent has not provided any detailed scientific evaluation of the potentially practically avoidable or irreversible impacts that the over abstraction rate at 9GL/a may cause.	This Supporting Document provides the EIA for abstraction at 6GL/a and the likely impacts at 9GL/a (to 2027) based on historical monitoring and impacts observed at abstraction volumes at or greater than 9GL/a. The EIA undertaken outlines that the groundwater pools are predominately fed by significant climatic events, with poor correlation between pool levels with median aquifer levels. Previous abstraction volumes and monitoring data has shown groundwater abstraction volumes greater than 9GL/a (up to 16GL/a). All pool water levels recovered. These impacts are not expected given the proposal is for a lower ongoing abstraction volume and a temporary contingency period. No long-term significant impacts to pool water levels are expected as a result of implementation of the proposal.
Water levels in Peters,	High abstraction rates causing a significant drawdown of the watertable have led to extended breaches of the	Previous monitoring data has been used to determine the potential environmental impacts of groundwater abstraction at the proposed temporary contingency abstraction volume to up to 9GL/a. There have been three periods where

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Woodley, and Palm Creeks	current operating management conditions of the Millstream aquifer which are meant to ensure streamflow in Peters, Woodley, and Palm Creeks. However, Peters and Woodley Creeks have been drying for the past 9 months.	groundwater abstraction has been at or above 9GL/a, 1978-1985, 2001-2004 and 2012-2013. During 1978-1985, groundwater abstraction was up to 11GL/a plus an additional abstraction for supplementation, totalling 16GL/a. During this period, below average flows through the Fortescue were observed between 1976 and 1983, including a three-year hydrological drought between 1976-1978. The Deep Reach pool levels started to show decline after three years, declining from 291.90 mAHD to 291.35 mAHD (0.55 m decline), and recovered following supplementation. No long-term impacts to pool water levels from higher levels of abstraction were observed, as pool water levels recovered. During 2001-2004, groundwater abstraction was up to 9.6GL/a with no supplementation. Between 2002 and 2003 below average flows were also observed in the Fortescue River. The pool levels were generally constant during this time at Deep Reach pool with no significant reduction in pool water levels. Pool levels showed a decline after the first year at Chinderwarriner pool. Pool water levels recovered in 2004 following almost 545GL of flow through the Fortescue River during the 2003-2004 wet season. During 2012-2013, groundwater abstraction was up to 9.2GL/a with no supplementation. The pool levels were generally constant during this time with no significant reduction in pool water levels. Previous monitoring data and abstraction volumes (2001-2003 and 2012) has shown short term abstraction of up to 9GL/a does not result in significant long-term impacts to the pool water levels of the Millstream Wetland. The proposed temporary contingency abstraction volume to up to 9GL/a is therefore not expected to result in long-term significant impacts to pool water levels.
Fauna monitoring	None of the thresholds, triggers or monitoring actions required for existing and proposed groundwater abstraction licences require a direct assessment of impacts to fauna. The current management framework is therefore	Pool water levels measured as the pool cease to flow (CTF) and salinity are used to monitoring fauna habitat and impacts to fauna. Pool stage height data has been used to assess the connectivity between the pools where, the pool stage height in the most downstream pool (Livistona pool) is above then outflow and inflow is assumed to be occurring, and upstream connectivity maintained. Livistona pool stage data remained above the CTF during the reporting period, indicating Deep Reach pool has been sufficient to maintain the connectivity of surface water

Aspect	YAC Comments	Water Corporation Responses
	inadequate to describe the potential impacts of the proposed licence renewal.	downstream to Livistona pool. It has also been demonstrated that there is no correlation between Deep Reach spring discharge and the occurrence and duration of no flow at Gregory Gorge, indicating any observed impacts at Gregory Gorge are not attributable to the proposal and likely to be caused by the absence of wet conditions and a recent tropical cyclone. Salinity concentrations have also generally remained within monitoring criteria outlined in the WRMOS.
Impacts to fauna	Vegetation loss, the drying of pools, changes in seasonal availability of water, water depth changes, salinity changes, temperature changes and erosion and associated changes in total suspended solids are all possible and likely outcomes of abstraction above the sustainable yield of the aquifer.	Historical monitoring was shown that the Livistona pool stage data remained above the CTF during the reporting period, indicating Deep Reach pool has been sufficient to maintain the connectivity of surface water downstream to Livistona pool. It has also been demonstrated that there is no correlation between Deep Reach spring discharge and the occurrence and duration of no flow at Gregory Gorge, indicating any observed impacts at Gregory Gorge are not attributable to the proposal and likely to be caused by the absence of wet conditions and a recent tropical cyclone. Salinity concentrations have also generally remained within monitoring criteria outlined in the WRMOS.

Reported failures to comply monitoring conditions	Documents produced by the Corporation pursuant to the Freedom of Information Act 1992 (WA) (FOI Act) show repeated failures to comply with monitoring conditions, including for a period of 11 consecutive months at two monitoring bores due to "mechanical issues". As at the date of this referral, DWER has failed to respond substantively to requests for information made under the FOI Act on 3 July 2024.	Compliance is assessed by taking into account the reason for any missed monitoring and whether DWER were notified of the missed monitoring.
		
		Missed monitoring is categorised as controllable or uncontrollable. Specific definitions for controllable and uncontrollable misses are provided in the Water Corporation's Management of Non-compliances and Breaches procedure (#9092803) and are summarised as:
		
		• A controllable miss is defined as missed monitoring or sampling (required by the WRMOS, licence or permit) that could have been taken with reasonable preparation, planning and performance of employees.
		• An uncontrollable miss is defined as missed monitoring or sampling (required by the WRMOS, licence or permit) that could not be taken due to an unforeseen event, due to compromised safety or access or due to equipment failure or planned maintenance when:
		    ○ there is no alternative method for sampling (i.e. tape reading) at the bore,
		    ○ there is no opportunity to reschedule within the one-week sampling tolerance period; and

Aspect	YAC Comments	Water Corporation Responses
		○ the repairs/mitigation are being carried out within the agreed timeframes. Uncontrollable misses may change classification to controllable, when no action is taken to reinstate the monitoring within the standard or agreed timeframe and no action has been made to communicate with DWER to agree a revised timeframe. This allows for extension to the agreed timeframe by prior agreement with DWER. Uncontrollable misses, such as those reported to DWER in the 2023-2024 Water Monitoring Summary, are not considered by DWER to be a failure to comply. The reported instances of uncontrolled misses, the agreed actions and follow-up commentary are as follows: • Production Bore 2 and Production Bore 3 both missed conductivity and annual major readings in June 2023 due to bores being offline for mechanical issues. Sampling will resume once pumps are repaired. ○ *Follow-up: Both bores came back online in early 2025 and have since been sampled as required*. • Decommissioned Production Bores 7 and 8 missed their annual conductivity sampling as the pump and headworks have been removed. • In August 2023, in recognition, the Corporation requested the requirement be removed from the WRMOS. The removal of this requirement was informally endorsed by DWER in July 2023 conditional on the addition of sampling of a nearby monitoring asset 5B-20. The agreed compromise was included in the Draft WRMOS forwarded as a component of the April 2024 6GL Licence renewal application. ○ *Follow-up: The Corporation is also in the process of procuring third party services to assess the condition and obtain water quality samples at Production Bores 7 to 9 and Monitoring Bores 10 to 12 as a part of its investigation into redistributing drawdown.*
Pool water levels	The analysis identified that all pools generally held a declining trend for the preceding 10-years, meaning the surface area and volume of the pools are reducing.	The change to pool water levels at Deep Reach pool has been within approximately a 1m range, with levels recorded at 292.61 mAHD in 2006 to 291.53 mAHD in 1988, with the exception of the period of 1979 to 1982 when abstraction reached 16GL/a. The pool water levels are erratic, characterised by 0.5m peaks associated with tropical cyclones and flows feeding the Fortescue River during the wet season.

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		Figure 25 shows that in recent years, the peaks are not as variable, reflecting a more median trend in rainfall, but the overall trend is consistent with pool levels since 1990. The most recent reading of 291.92 mAHD in January 2025 is generally consistent with the pool levels since 1990 (291.86 mAHD in 1990). The pool water levels at Chinderwarriner pool have ranged by around 0.2m from 293.13 mAHD in 1989 to 293.32 mAHD in 2006, with the exception of the period of 1981 to 1985 when abstraction reached 16GL/a. Monitoring at Chinderwarriner pool ceased in 2014 and was replaced with monitoring from bore 1E (Figure 26). Groundwater levels peaked in 2000 due to tropical cyclone Steve and 2006 due to tropical cyclone Clare followed by tropical cyclone Emma C1 (largest recorded recharge event). The pool levels as measured at bore 1E have since receded to levels observed prior to these events. The average discharge volumes from the Millstream aquifer to Deep Reach pool observed at Crossing pool between 2014 to 2024 is 7.9GL/a, Chinderwarriner pool is 10.2GL/a, and small springs west of Chinderwarriner pool including Woodley, Peters, and Palm Creeks is estimated discharge 0.23GL/a (Water Corporation, 2024). Given the average annual flow into the Millstream Wetland pools from the Fortescue River (recorded at DWERs downstream Gregory Gorge Gauging Station) for the 2014 – 2024 period was on average 115.5GL/a, springflow from the Millstream aquifer therefore presents almost 16% of total flow recorded at Gregory Gorge with water sourced from the Fortescue River presenting just over 84%. Any lowering of the watertable due to the proposal is not likely to impact water levels in Deep Reach and Chinderwarriner pools as the main water source for these pools is flow through the Fortescue River which is a system reliant on rainfall generated runoff from tropical cyclones and flows during the wet season. Livistona, Palm and Crossing pools are fed by surface water moving through the Fortescue as well as springflow generated overflow from Deep Reach pool and tributaries such as Chinderwarriner. Any water level decline in these pools cannot be solely attributed to the proposal and may be attributed to other factors, such as local hydroclimatic conditions. The pools at Woodley, Peters and Palm Creek are fed from low background volumes of springflow from the aquifer and from runoff generated by significant climatic inputs. Any reduction in springflow attributed by the proposal is not likely to

Aspect	YAC Comments	Water Corporation Responses
		impact the water levels in the pools, as background volumes are low and pools levels are likely to be supplemented by catchment runoff.
Salinity	Some evidence suggests that salinity in Chinderwarriner pool increases in response to groundwater abstraction (Millstream Chichester National Park and the Mungaroona Range Nature Reserve Management Plan, 2011), however, no follow up monitoring has been undertaken to confirm this.	Refer to Figure 39 to Figure 40 for monitoring results for salinity at Deep Reach Chinderwarriner and Crossing pools. Based on this DWER set a 1400 mg/l TDS target at Deep Reach pool and 1086 mg/L at Chinderwarriner pool to maintain fauna health. Water quality of Deep Reach and Chinderwarriner pool indicates: • TDS in the Deep Reach pool typically ranges between 220mg/l to just over 1400mg/L (Figure 39). • Chinderwarriner pool salinity complied with Trigger of 1086 mg/L with the exception of one monitoring event (1,392mg/L in December 2015) (Figure 40). Over the last eleven years of monitoring the target has been passed twice in January 2023 and January 2024. These higher values both precede significant drops in TDS and correspond with significant elevations in pool level. Analysis indicates these events correspond with flow events at Gregory Gorge. These peaks hence likely reflect an initial flush of TDS from the upstream catchments during the initiation of wet season flows. These levels are still well below salinities known to impact on fish and macroinvertebrates (DWER, 2019).
MAL and historical abstraction volumes	Periods of sustained high rates of abstraction (i.e. 3-years or more), including 1976-1985 and 2001–2003 and 2012, similar to that proposed by the Water Corporation of 9GL/a clearly correlate with drastic declines in monitoring groundwater levels at the key monitoring bores.	Figure 30 presents the Millstream MAL and historical groundwater abstraction volumes. Sustained high rates of abstraction greater than 9GL occurred between 1978 and 1985 including a period of sustained abstraction in excess of 13GL between 1981 to 1984. The impact on the aquifer was further exacerbated by extremely low riverflow and recharge including a 3-year hydrological drought. As a consequence, in 1984 the MAL reached a minimum observed level of 293.02. The annual average rate of MAL decline during this period was 0.115 m. The proposal is to abstract a total of 6GL/a, with an additional contingency of 3GL/a to 2027 subject to source development progress and water availability in Harding

Aspect	YAC Comments	Water Corporation Responses
		Dam. The 1978 to 1985 period is not comparable in both proposed duration or magnitude. A three-year period of abstraction greater than 9GL occurred in 2001 –2003 coinciding with a 2-year hydrologic drought between 2002 and 2003. During this period Millstream was the sole source, Harding Dam was offline due to an inability to achieve compliance with drinking water quality guidelines. The Harding Dam water treatment plant was commissioned in 2004, During this period the MAL dropped from a record high (at the time) of 294.575 to 293.780 mAHD. The average annual rate of decline 0.237 m. It is noted that this rate of decline is less than that observed between 2004 to 2006 (0.312 m) 2006 to 2008 (0.295 m) and 2009 to 2010 (0.51 m). In these subsequent periods annual abstraction was less than 2.3GL, 1GL and 2.5GL per annum respectively. A one-year period of abstraction in excess of 9GL occurred in 2012. During this time the MAL dropped from its May 2011 peak of 294.718 to 294.32mAHD and then subsequently recovered to 294.525 mAHD following Tropical Cyclone Christine. Modelling to date indicates that, irrespective of abstraction, when peaking above 294.5 the MAL exhibits an average rate of recession of 0.350m per annum. There is no clear correlation between rates of abstraction up to 9GL and declines in the MAL levels as illustrated by periods of low abstraction (2004 to 2006, 2006 to 2008 and 2009 to 2010) which showing similar or greater rates of decline.

MILLSTREAM GROUNDWATER STUDY

Assessment review

Requested by:	Environmental Business Unit
Prepared by:	Principal Hydrogeologist
Team:	Water Resource Science
Date:	4/04/2025
Nexus ID:	189294233
Version:	2.0

1 Summary

Yindjibarndi Water (YW) have developed a groundwater study (the Study) (Millstream Groundwater Study, 2024) to supplement a third-party referral to the Environmental Protection Authority (EPA) to assess a Water Corporation application for a groundwater licence entitlement renewal for the Millstream borefield. The Study's objective is to review historic observation data and perform statistical data analysis to assess the current state of the aquifer, determine the cause of aquifer decline, and by extension environmental stress, and recommend sustainable operational practices including sustainable abstraction yield.

This advice provides a technical review of the Study report to reconcile assessment methodologies and associated statements made in the Study against a large body of literature and understanding of how stresses on the Millstream Aquifer system may manifest on the monitoring record and impact associated environmental, social, and cultural values.

2 Background

The Millstream borefield accesses groundwater from the Millstream Dolomite, a significant aquifer across the Fortescue Valley. The Millstream aquifer is a dual porosity system which contains large voids or caverns and as a result the unit is extremely transmissive, bore yields are generally high and pumping tests carried out in this formation generally yield extremely low levels of drawdown induced by high levels of pumping (Barnett, 2010). Recharge to the aquifer occurs via direct infiltration of rainfall in the area where the aquifer is unconfined, seepage from small streams that drain the Hamersley and Chichester Ranges, and seepage from the Fortescue River and associated flood plain. These recharge mechanisms are complex, occurring predominately in relation to cyclonic rainfall events. As the primary mechanism for recharge to the aquifer is the contribution of sporadic surface water flows from a catchment significantly larger than the borefield area, the estimation of recharge volumes and aquifer yield is challenging.

The Department of Water and Environmental Regulation (DWER), in recognition that the long-term sustainable yield of the aquifer is relatively low due to the variability of recharge set a long-term reliable allocation of 6.0 GL/yr which was assessed to maintain discharge to the river pools within and downstream of the Millstream Chichester National Park to be met with approximately 80% reliability (DWER, 2010).

There is a large body of literature and research that have described the hydrogeology and relationship between climate, recharge and abstraction in the Millstream area. The Yindjibarndi

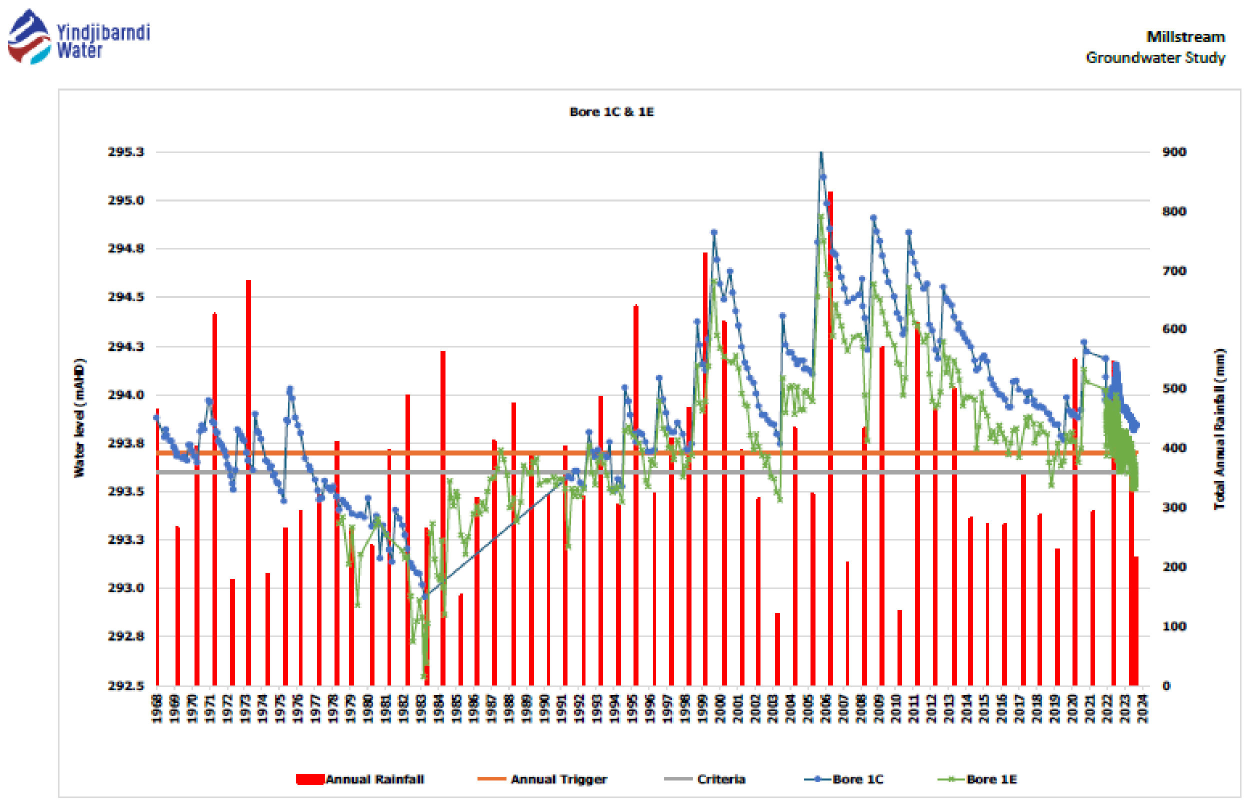
Study provides a summary literature review and recognises the comprehensive understanding of the hydrogeology and aquifer system that has been developed over the last fifty years. The Study's technical summary of the area's geology, hydrogeology, groundwater discharge, and recharge is accurate, being largely referenced excerpts from the body of work summarised in the literature review. The relationship between river flow and aquifer recharge is specifically referenced, stating that "Previous studies have shown a strong correlation between river flow and water levels in the unconfined portion of the Millstream Dolomite (Barnett and Commander 1986)."

3 Review

Executive Summary

The Study states "*Over the past 50 years, variable high levels of groundwater extraction have led to severe environmental consequences, including loss of vegetation, drying of creeks, and damage to culturally significant sites*" (page 6). This statement on environmental consequences has been made without undertaking an environmental impact assessment, "This Study has not had the scope and funds to review the environmental impacts independently in a conventional manner which is a part of the recommendation for next steps" (page 6).

The executive summary references monitoring bores 1C and 1E, reproducing hydrographs alongside abstraction and rainfall data. The Study states these graphs are "*The illustration of these breaches of a water system out of balance when abstraction levels are above 4Gl/year in a dry year, are demonstrated in the following two slides for monitoring bores 1C and 1E"* (Page 10). There is no reference to the strong correlation between the water levels and rainfall also demonstrated by the graphs or that there is a link between rainfall and abstraction i.e. in dry periods and when Harding dam has low storage, more abstraction is required.



Bores 1C and 1E are located close to production bores and have frequently breached the criteria and trigger levels outlined in the operating strategy. Continuing without intervention could lead to long-term depletion of groundwater resources, resulting in significant ecological and socioeconomic impacts.

Climate

The report presents a brief description of the climate type for the area, summary statistics for the 1968-2023 rainfall record and reproduces a graph of rainfall for the same period. An analysis or discussion of rainfall trends is not discussed, nor how the frequency of cyclone events has changed over this period. Temperature and evaporation do not feature in the climate section. Water Corporation considers a discussion on climate is required, given the influence of climate on the groundwater resource and associated environmental and cultural values.

Groundwater monitoring and observations bores

Section 7.2 of the report presents the (MAL) monitoring data with abstraction and rainfall on separate graphs, with separate descriptions. Hydrograph trends are described but do not consider the influence of recharge as a mechanism for water levels. The Groundwater Level Vs. Annual Rainfall descriptions typically describe water level trends and the relationship to trigger values and excludes cyclones or rainfall events, or droughts which influence levels.

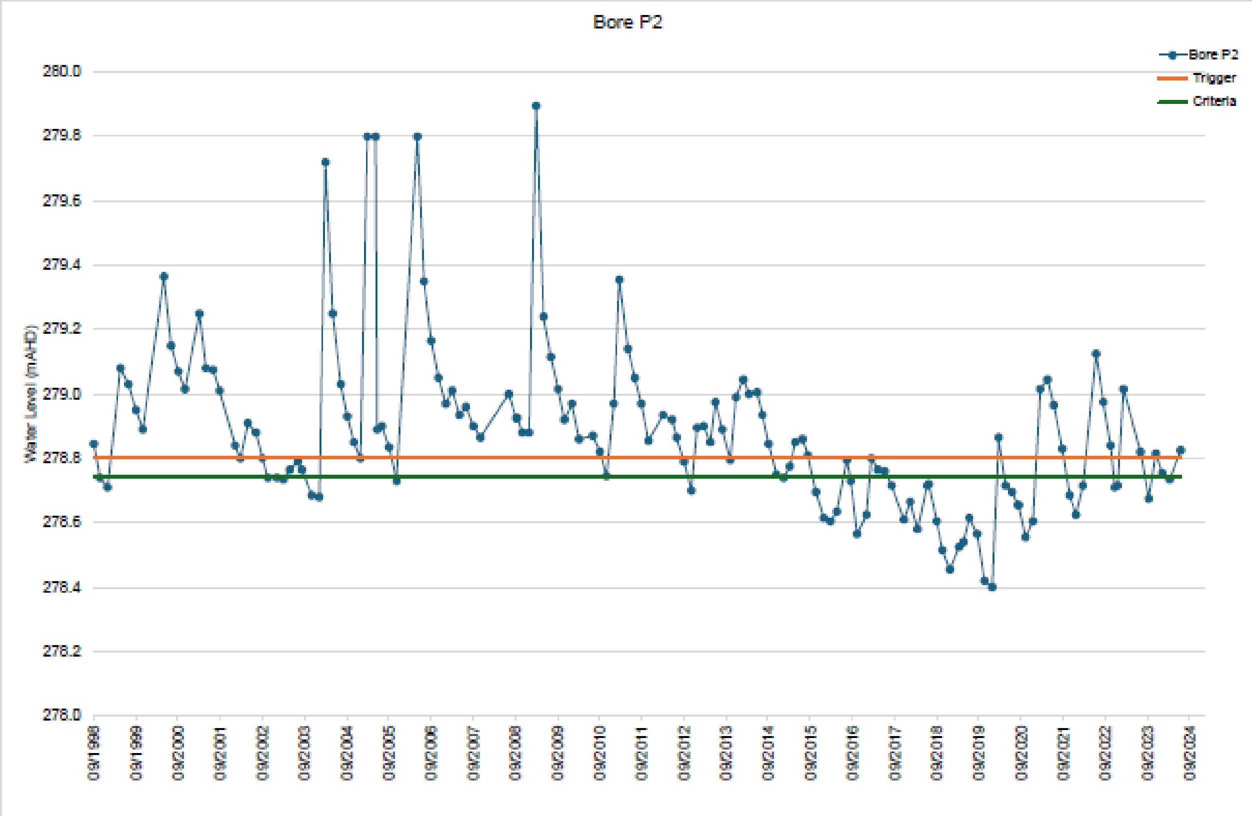
The Groundwater Level Vs. Annual Abstraction descriptions describe water levels and abstraction levels over the monitoring record in a similar way to the Rainfall description *"There is an inverse relationship between water levels and the volume of groundwater abstraction. Years with high abstraction coincide with significant drops in water levels, suggesting that the groundwater system is highly sensitive to the volume of water extracted"* (Page 42). The relationship with rainfall is not included *"Although rainfall impacts water levels, the overall downward trend indicates that abstraction is the primary driver of groundwater depletion*" (Page 54). There are periods where abstraction generally reduces, such as 2014 to 2019, but the groundwater levels also decline. For the last 20 years it is not conclusive that there is a relationship between water levels and abstraction.

The observation record from 1968 is complex, due to the construction of Harding Dam, so the relationship with Harding Dam storage and abstraction and recharge to the borefield that cannot be captured by the single Millstream Weather station that provides rainfall data for the graphs.

Environmental Observation Bores

Section 7.3 describes environmental monitoring bore trends. The hydrographs are displayed on separate graphs and pages and do not include climate or abstraction data to inform trend analysis.

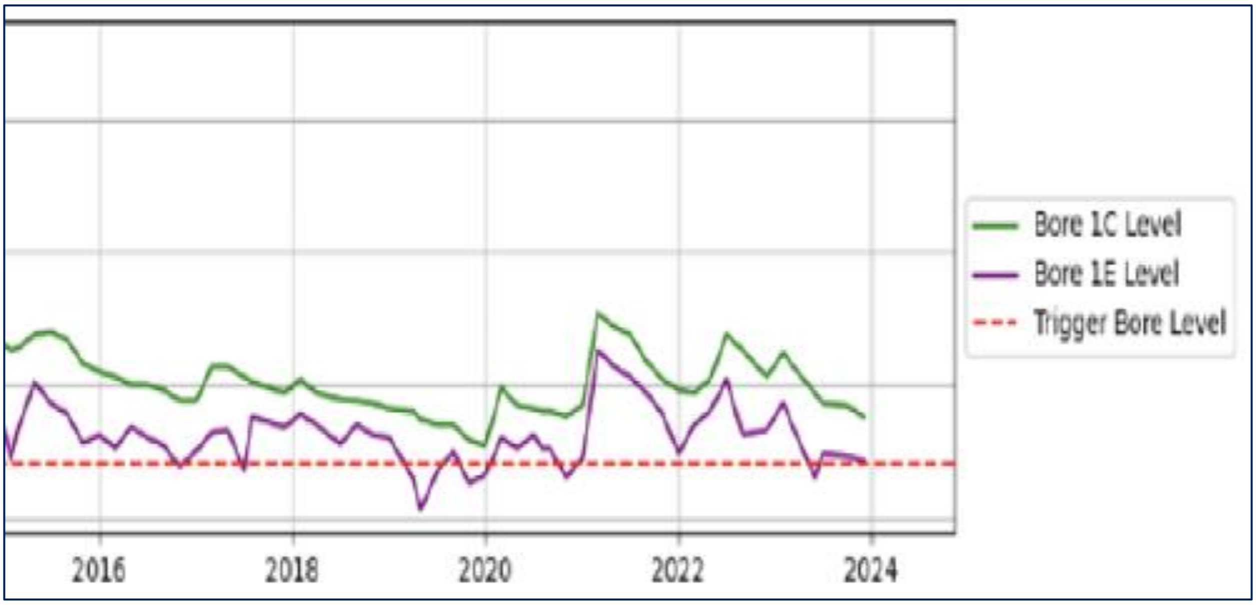
The Study states a "*general downward trend*". There are significant periods of stability and upward trends in the monitoring records. Observation bore P2 is described *"In recent years, there have been fluctuations around the trigger level, but the general trend remains downward."* (Page 62). There is an upward trend for the last 5 years and there is one downward trend between 2013 and 2019 (which reflects rainfall decline over this period). The current levels are similar to the start of the data series in 1998, as is the case for many of the bores.



Statistical Data Analysis

The report states statistical methods have been used gain a deeper understanding of the relationship between water levels, abstraction rates and rainfall in the Millstream area. However, one bore has been used in the analysis *"water level data from bore 1E, along with abstraction and rainfall data, were used to assess the correlation between drawdown and abstraction rates"* (Page 85). Bore 1E is the nearest site to the production bores at ~200 m away so would provide the strongest response to abstraction and not represent a useful indicator of aquifer health or its relationship with rainfall, with the aquifer being over 30 km in length and responding to recharge from a surface water catchment of approximately 40,000 km^2. A broader suit of monitoring data from bores across the aquifer resource is available and would be required to provide suitable analysis.

Under the Key Observations section, the hydrographs for bores 1E and 1C are presented with the introductory statement *"The bore levels have been in a constantly declining trend since 2015 and closer to the trigger level for an extended period."* (Page 85). However, there was a significant recovery of levels in 2020 following a cyclone, followed by a decline meaning that recent levels for both bores are a similar elevation to that of 2015 (see below) and that a total decline over this period is not prominent.



The close correlation between bore 1E (~200m from production bore 1) and bore 1C (~2km from production bore 6) is referenced by the Study, but the importance was not discussed. The close correlation is evidence of very high aquifer transmissivity which may indicate that the aquifer system responds to aquifer stresses such as climate and abstraction and that modifications to pumping distribution may have limited influence.

The analysis is underpinned by a "simple" water balance presented as *"(ΔS = R – E – A , where .S= Change in Storage, R = Rainfall, E = Evaporation, and A = Abstraction)"* (page 86). This equation cannot represent change in storage. Inputs to the system would be required to include recharge as a proportion of rainfall that enters the aquifer over the borefield/aquifer area, as well as the recharge derived from surface water systems including the Fortescue River. Outputs would also be required to include discharges to surface water systems such as Deep Reach Pool. The stated water balance equation does not reflect the conceptual understanding of Millstream system, including those developed for multiple models.

The recharge section (5.2.2) notes that "*Recharge to the Millstream aquifer occurs through various mechanisms, including rainfall infiltration in outcrop areas, seepage from streams draining the Hamersley and Chichester Ranges, seepage from the Fortescue Riverbed, and floodwater infiltration during heavy cyclonic rainfall events"*. The primary recharge mechanisms and groundwater flow (discharge) are absent from the water balance equation.

The Study rainfall and evaporation measurements, including cyclones as part of the water balance. The full description of the Statistical Data Analysis presented in Appendix 8 does not provide further information to address these gaps with the exception that the period from 2015 – 2023. The full description of the analysis excludes reference to recharge, with rainfall as the only system input.

The report states that the above water balance formula *"returns a set of negative values for the period indicating that the Millstream system is constantly under stress and requires a significant increase in rainfall, and/or a subsequent decrease in abstraction. More water during this period is being abstracted than replenished by the rainfall"* (Page 86). This statement applies for any period of time between cyclone events, a negative change in storage from the above water balance equation can be explained by the lack of surface water catchment and river recharge which was omitted from the water balance. The water balance period of 2015-2023 is a period of lower rainfall with an annual average of ~350 mm compared to 434 mm over the preceding 10 years. There is no analysis of rainfall distribution, intensity and distribution of cyclone events or how evaporation has changed over time.

A statistical methodology is presented (Section 9.2). The method reduces the normalised difference between water levels (at 1E) and target level (293.7 m AHD) to a factor that is then used to scale abstraction values over the same time series. The result is a scaled abstraction record to achieve a better compliance with the target level demonstrated with a scaled water level record. An associated reduction in abstraction from 6 to exactly 4 GL is recommended by, "*A calculation was used to provide a forward 12-month trend, and the analysis concludes that the abstraction rate should be less than / equal to 3.97GL/a."* (Page 87). The calculation for the forward trend and calculated reduction in abstraction is not provided in the Study. Any forward projection relating to the method described would require an assumed water level, and by extension assumed rainfall recharge which was not discussed.

The above method is not a suitable analysis tool as it assumes that the relationship between water level and a target level is influenced by abstraction only, and that changes in abstraction can compensate for any change in water level. This discounts the significant impact of climate on water levels which would change the statistical relationship between water levels and abstraction.

The method description for calculating the (scaled) water balance states that "*The water balance is computed by subtracting the scaled abstraction and evaporation from the rainfall. This gives a Scaled Water Balance*" (Page 88). The water balance (scaled or otherwise) does not influence the analysis to calculate (scaled) abstraction, being a product of the relationship between water level and abstraction only. The calculation to scale and reduce abstraction does not appear to include the water balance equation, therefore, the statement *"By scaling the abstraction, the function maintains the bore level close to the target value of 293.7, while accounting for the effects of evaporation and rainfall on the water balance"* (Page 88), is not appropriate. The calculation for the scaling factor used to manipulate abstraction does not include the water balance or climate inputs.

It is noted that the scaling is indirectly influenced by climate because the water level elevation is strongly correlated with rainfall. Reverse engineering of reduced abstraction to fit water level data is not a suitable methodology for reduced abstraction into the future. This is because storage in the Millstream Aquifer is driven by complex recharge and discharge mechanisms including primary recharge derived from surface water flow contributions from a catchment far larger than the aquifer area.

Additional assessment methods including machine learning and XGB regression are referenced. These methods also use the scaled abstraction data as an input and not suitable by the assumption that the relationship between water levels and abstraction is exclusive.

The results Section (Section 9.3) of the Statistical Assessment and the final section (Section 6) of Appendix 8: Millstream Statistical data Analysis provides an analysis of: "*Analysing the Relationship Between Bore 1E Levels and 12-Month Rolling Sum Rainfall*" (Page 221). The analysis uses 12 month rolling average in rainfall and compares with water levels at bores 1E. This analysis recognises the relationship with bore levels, compliance and rainfall concluding that *"The plots collectively demonstrate the relationship between Bore 1E levels, rainfall, and the water balance. When Bore 1E levels fall below the target, it's often correlated with a negative trend in the rolling 12-month rainfall, indicating insufficient rainfall to recharge the groundwater. By examining the water balance plot, you can also infer that abstraction plays a role in these fluctuations, but rainfall remains a critical factor for maintaining bore levels within the desired range"* (Page 222).

The comments and conclusion for these sections reflect an understanding of the system that is consistent with the literature, previous assessments and models. The findings of this section do not align with the general narrative the Study which is that abstraction is the driving force behind non-compliance with target levels and water level decline.

Discussion and Recommendation

The Discussion and Recommendations Section (Section 13) of the Study concludes that;
"***Reduced Extraction Rates****: The analysis of groundwater levels in MAL 8 bores clearly demonstrates that high abstraction rates have led to significant declines in water levels across the Millstream aquifer system"* (Page 103). This statement is inconsistent with the rolling average rainfall analysis but consistent with the remainder of the Study.

The recommendation of integrated surface water and groundwater modelling to re-assess the sustainable yield of the Millstream Aquifer is appropriate, as are the remaining recommendations. The analysis and associated discussion presented in the Study is inappropriate to justify a reduction in abstraction. The hydrograph assessment and statistical assessment does not acknowledge the conceptual understanding of the aquifer system, particularly that system inputs cannot be represented by rainfall alone. A comprehensive water balance model may assist further analysis but is required to include groundwater discharges as outputs and recharge from surface water inputs derived outside of the aquifer area.

4 Summary

The Study delivers a recommended future abstraction limit of 4 GL/yr. The report, and appendices do not describe specifically how this number was calculated. Therefore, a review of the methodology to calculate the specific recommended abstraction volume is not possible.

The Study does not include climatic inputs into the conceptual understanding of the Millstream aquifer system. This is demonstrated by statistical/analytical methodology that abstraction is fundamentally driving water level decline and that reducing abstraction can compensate for declines and non-compliance. Some citations and discrete elements of the Study recognise surface water recharge as a primary system input, this is contrary to the statements made, which reduces the influence of climate as secondary to abstraction with recharge being represented by measured rainfall only.

This review recommends that the Millstream Groundwater Study is not used to propose abstraction volumes from the Millstream Aquifer.

5 References

Department of Water (DoW). 2010. Millstream aquifer – determination of a long-term sustainable yield and long-term reliable allocation. Department of Water Allocation Planning Series Report No.42, June 2010.

Barnett, J. C. and Commander, D. P., 1986. Hydrogeology of the Fortescue Valley, Pilbara Region, Western Australia. Western Australia Geological Survey record 1986/8, Perth 1986.

Commander, D.P. (1993). Hydrogeology of the Fortescue River Alluvium. Hydrogeology Report No 1993/94. Western Australia Geological Survey Perth, 1993

Appendix D: West Pilbara Water Monitoring Review 2018-2021

West Pilbara

Water Monitoring Review

2018 - 2021

Confidential

October 2021

Confidentiality Notice

This document is confidential.

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Operational Asset Management Business Unit
Assets Performance Group
Water Corporation

West Pilbara
Water Monitoring Review
2018 – 2021

October 2021

This monitoring review has been prepared for the Department of Water and Environmental Regulation as a requirement of the Water Resource Management Operation Strategy for this scheme. The review provides an overview of compliance and resource performance for the review period.

Report prepared for:

Process Manager: Manager, Asset Strategy Business Unit

Scheme Operator: Regional Manager, North West Region

Regulator: Department of Water and Environmental Regulation

PROJECT TEAM:

Author –	Ahkim Edwards, Acting Support Analyst – Regulatory Compliance
Data analysis -	Ahkim Edwards, Acting Support Analyst – Regulatory Compliance
Graphics -	Grecian Dempster, Analyst GIS
Technical review –	Joe Miotti, Specialist – Regulatory Compliance Jacquie Bellhouse – Resource Investigation
Endorsement –	Tyrone Sun, Manager – Integrated Water Cycle Planning, Asset Investment Planning Regional

Corporate Document No. Document No. 123079302

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West Pilbara Water Monitoring Review 2018 – 2021
Corporate Document No. ***123079302***

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Related Documents

This report covers the current review for the scheme and may supersede, either partially or in whole earlier reports. The reader should refer to any documents listed below for complete information on this scheme.

Report Title	Date Issued	Document Number
West Pilbara Water Resource Management Operation Strategy	August 2014	58530778
West Pilbara Water Supply Scheme Water Monitoring Summary 2018/19	July 2019	77458264
West Pilbara Water Supply Scheme Water Monitoring Summary 2019/20	July 2020	100652250

Report Signatures

Endorsement

Developed by		Date	29.10.21
Name	Ahkim Edwards		
Position	Author Acting Support Analyst – Regulatory Compliance		
Technical review by		Date	29.10.21
Name	Joe Miotti		
Position	Technical reviewer Specialist – Regulatory Compliance		
Endorsed by		Date	29.10.21
Name	Tyrone Sun		
Position	Endorsement Manager – Integrated Water Cycle Planning, Asset Investment Planning Regional		

Contents

Figures

Tables

Abbreviations, Acronyms and Units of Measure

The following common abbreviations and acronyms may be used within this report:

AHD	Australian Height Datum
bTOC	Below top of casing
Cond	Conductivity
DWER	Department of Water and Environmental Regulation
EC	Electrical conductivity
EWR	Ecological Water Requirement
GDEs	Groundwater dependent ecosystems
GRANGE	Water Corporation customer service information system
Max	Maximum
Min	Minimum
NHMRC	National Health and Medical Research Council
NPR	National Performance Report
NWR	North West Region, Water Corporation
OAM	Operational Asset Management, Water Corporation
ODSS	Operational Data Storage System
RIWI Act	Rights in Water and Irrigation Act 1914
SWL	Static water level
TDS	Total dissolved solids
Temp	Temperature
TFSS	Total filterable solids by summation
TWL	Top water level
TWS	Town water supply
WC	Water Corporation of Western Australia
WPWSS	West Pilbara Water Supply Scheme
WRMOS	Water Resources Management Operation Strategy

The following common units of measure may be used within this report:

GL	Gigalitre (or 10^9L)
kL	Kilolitre (or 10^3L)
kL/d	Kilolitre per day
kL/unit/yr	Kilolitre per water service unit per year
km	Kilometres (or 10^3m)
L	Litre
m	Metre
mm	Millimetre
m^3	Cubic metres
ML	Megalitre (or 10^6L)
mS/m	Millisiemens per metre
yr	Year
ºC	Degrees Celsius
%	Percentage

National Performance Report (NPR) definitions and calculations used in this report:

Term	Definitions Consistent with National Performance Framework
Annual Water Entitlement	Quantity of water (kL) permitted to be taken annually, as stated in the scheme's Department of Water and Environmental Regulation 5C Licence.
Total Abstraction	The total volume of water abstracted from the source during the reporting period. For the purposes of Water Corporation reporting for DWER licences it is equivalent to the total water supplied to the scheme. It is the sum of: – *Volume of water supplied - residential and non-residential* – *Unbilled Authorised Consumption* – *Water Losses*
Volume of water supplied – Residential and Non Residential	Total metered volume supplied to residential and non-residential properties for the reporting period.
Volume of water supplied – Residential	Total metered volume supplied to residential properties for the reporting period.
Connected Residential Properties – Water Supply	The number of connected residential properties in a scheme.
Unbilled Authorised Consumption (UAC)	Previously reported as *Known Losses.* Any authorised consumption for which a bill is not issued to a customer. This includes water used for fire-fighting and consumption for water service operations, such as scouring or flushing mains and storages as well as water treatment process water. Where the volume used is metered, the actual volume should be entered. The National Performance Framework specifies a default value of 0.5% of the total water supplied to allow for unmetered *unbilled authorised consumption*. This amount can be added to any metered volumes.
Water Losses	Previously reported as *Unaccounted Water,* it is the sum of: – unauthorised consumption (illegal use) – customer metering errors – real losses (e.g., bursts, leaks and overflows from tanks) Water losses as a percentage is calculated as follows: $\frac{\text{Total Abstraction – Volume of water supplied (Res \& Non Res) – UAC}}{\text{Total Abstraction}} \times 100$

1. Introduction

This water monitoring review assesses the performance of the West Pilbara Water Supply Scheme (WPWSS) for the period 1 May 2018 to 30 April 2021. The previous review of the source was completed in 2018 and assessed the period from 1 May 2015 to 30 April 2018 (Water Corporation, 2018).

The water year for this scheme is 1 May to 30 April. All data presented in this report represents events occurring over water years, unless otherwise stated.

The WPWSS is currently operated under Groundwater Well Licence No. GWL105696(7) for the Millstream Borefield and Surface Water Licence No. SWL105715(7) for Harding Dam. Each licence has an allocation of 15,000,000 kL/yr, as well as a conjunctive condition that the combined total draw under both licences does not exceed 15,000,000 kL/yr.

The scheme's risk categorises the WPWSS scheme as an advanced scheme as per DWER's *Regulatory Guideline no. 28 Guidelines for Water Corporation Reporting*. The licences expire on the 11/05/2024. Copies of the licences are contained within Appendix A.

The WPWSS is part of the Water Corporation's North West Region operations. The scheme supplies a number of major industrial and commercial customers located at the Burrup peninsula, Karratha and Dampier, including the gas plants, salt works, offshore supply bases and worker camps.

At the 2016 census, WPWSS had a population of 34,497 (Australian Bureau of Statistics, 2016). The total number of units connected to the WPWSS as of April 2021 was 10,233, including 8,341 domestic properties, and total scheme consumption for the 2020/2021 water year was just under 11,753,000 kL.

1.1 Scheme Description

Water for the West Pilbara Water Supply Scheme (WPWSS) is sourced from Harding Dam and the Millstream Borefield. The two sources operate in conjunction, with Harding Dam being used as the preferential source when quality and quantity allows. Water is sourced from the Millstream Borefield when use of Harding Dam is constrained. Figure 1.1 shows a locality plan for the scheme.

A new groundwater source was established at Bungaroo Creek in 2014 to meet water demands from Rio Tinto Iron Ore (RTIO). Abstraction is licensed to RTIO for an allocation of 10 GL/yr. In 2014, RTIO completed construction of a new water pipeline to link the Bungaroo Creek Borefield to the Corporation's existing water supply system. The Corporation has an agreement with RTIO to accept and transfer around 8 GL/yr of Bungaroo water source into the system to meet RTIO's short term (~ 5 years) demand of 7.5 GL/yr (note 0.5 GL/yr assumed in water losses). The Water Corporation is not required to report on the Bungaroo Borefield.

1.1.1 Harding Dam

Harding Dam is located on the Harding River about 30 km south of Roebourne. Its reservoir has a storage capacity of 63.8 GL. Water is drawn from the reservoir and passes through a microfiltration water treatment plant before entering the scheme's distribution system. Water treatment is required to achieve compliance with drinking water quality guidelines.

Since commissioning of the water treatment plant in 2004, Harding Dam reservoir has provided the bulk of the scheme supply up until 2012. When operating, a near continuous flow of supernatant water is released from the water treatment plant (approximately 5% of water production) downstream of the dam. The supernatant is the by-product of microfiltration water treatment.

In late 2019, Harding Dam was offline and remained offline for the rest of the water year due to low water levels and operational issues. Harding Dam was again offline from November 2020 due to water quality issues associated with increased Aboriginal customary access, contact with the water body within Harding Dam and lack of pathogen barrier in place to manage the risk of water contact. Harding Dam came back online in January 2021.

When Harding Dam is offline, abstraction from the Millstream Borefield is required. There is potential for environs downstream of the dam to be affected by dam operations. Figure 1.2 shows the location of the Harding Dam and the downstream environmental monitoring sites.

1.1.2 Millstream Borefield

The Millstream Borefield is located near the old Millstream Homestead, adjacent to the Fortescue River, about 130 km south of Roebourne. The borefield consists of six production bores that draw water from an unconfined aquifer within the Millstream Dolomite formation. A further six production bores 7 to 12 are currently unequipped due to high salinity. Water is pumped from the borefield, chlorinated, then transferred to two 9 ML summit tanks from where it gravitates into the distribution systems.

The Millstream area, most of which is within the Millstream Chichester National Park, is of major environmental, social and cultural importance. The natural pool and surrounding riverine ecosystems at Millstream rely on supply from the Fortescue River and the Millstream aquifer.

The borefield also includes two sets of supplementation bores, which are available to supplement nearby Deep Reach and Chinderwarriner Pools during extended non-recharge periods. Water is pumped from the supplementation bores into the pools when outflow rates from Chinderwarriner and Crossing Pools fall below the environmental water requirements trigger.

The mean aquifer level (MAL) is a critical monitoring factor that influences the operation of the borefield. There are 8 monitoring bores across the Millstream area, which are used to determine the MAL and these are known as the MAL8 (1C, 1E, 2B, 2C, 4A, 5B, 7C and 8C).

The location of all the production and monitoring bores for the Millstream borefield is shown in Figure 1.3. Details of the production bores are listed in Table 1.1 and on the bore information sheets in Appendix B.

Table 1.1 West Pilbara – Summary production bore details

Bore	Depth (m bTOC)	Screen Interval (m bTOC)	Maximum Recommended Pump Rate (kL/day)	Average Pump Rate 2020/21 water year (kL/day)
PB1	19.2	7.01-17.07	17,743	11,543
PB2	15.66	2.2-14.2	17,774	8,514
PB3	21.64	12.8-19.81	17,698	11,212
PB4	16.75	6.75-15.75	8,980	8,142
PB5	17.5	7.7-16.7	8,879	7,631
PB6	20.3	10.01-19.01	8,838	6,897

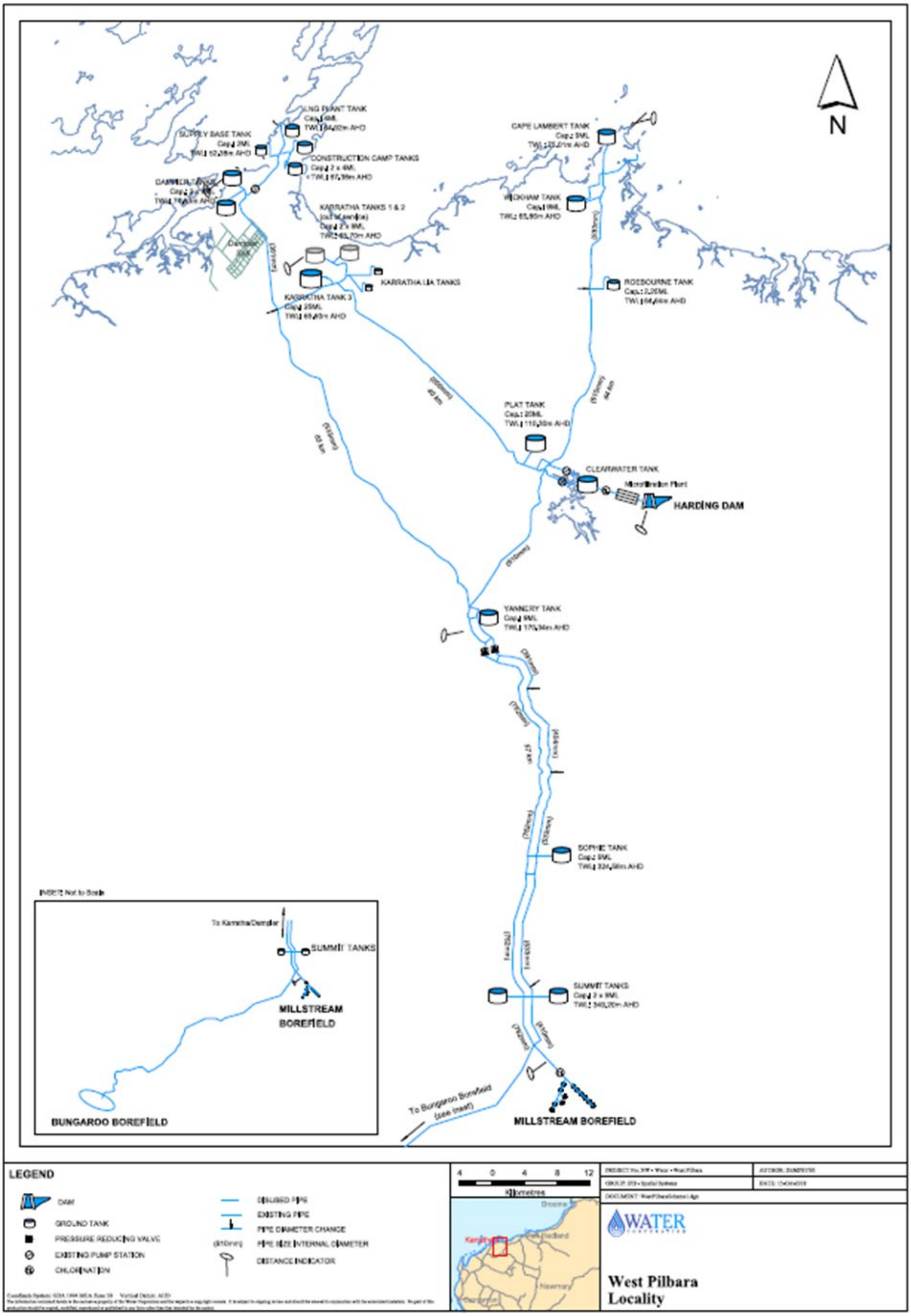


Figure 1.1 Locality plan

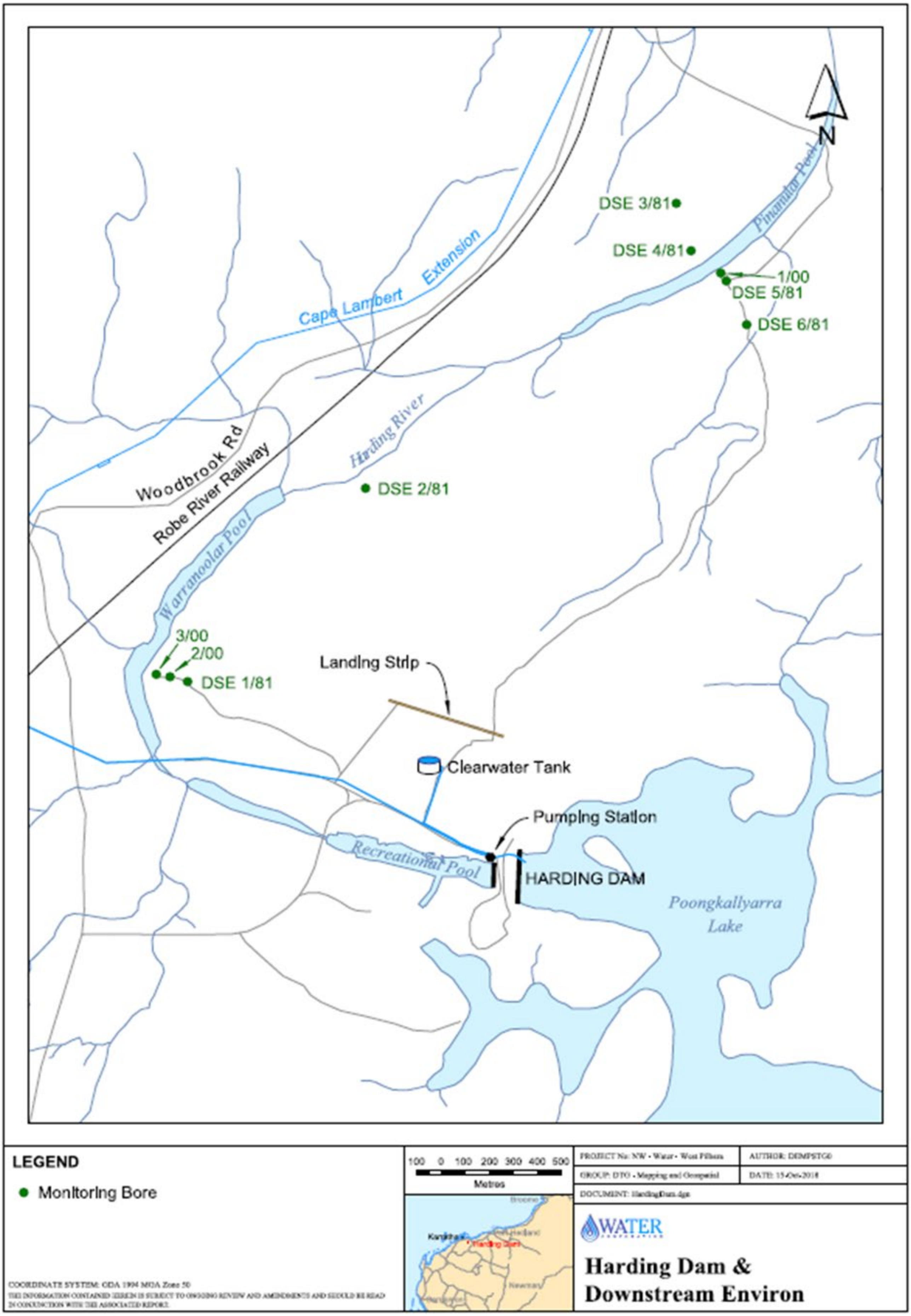


Figure 1.2 Harding Dam and Environs

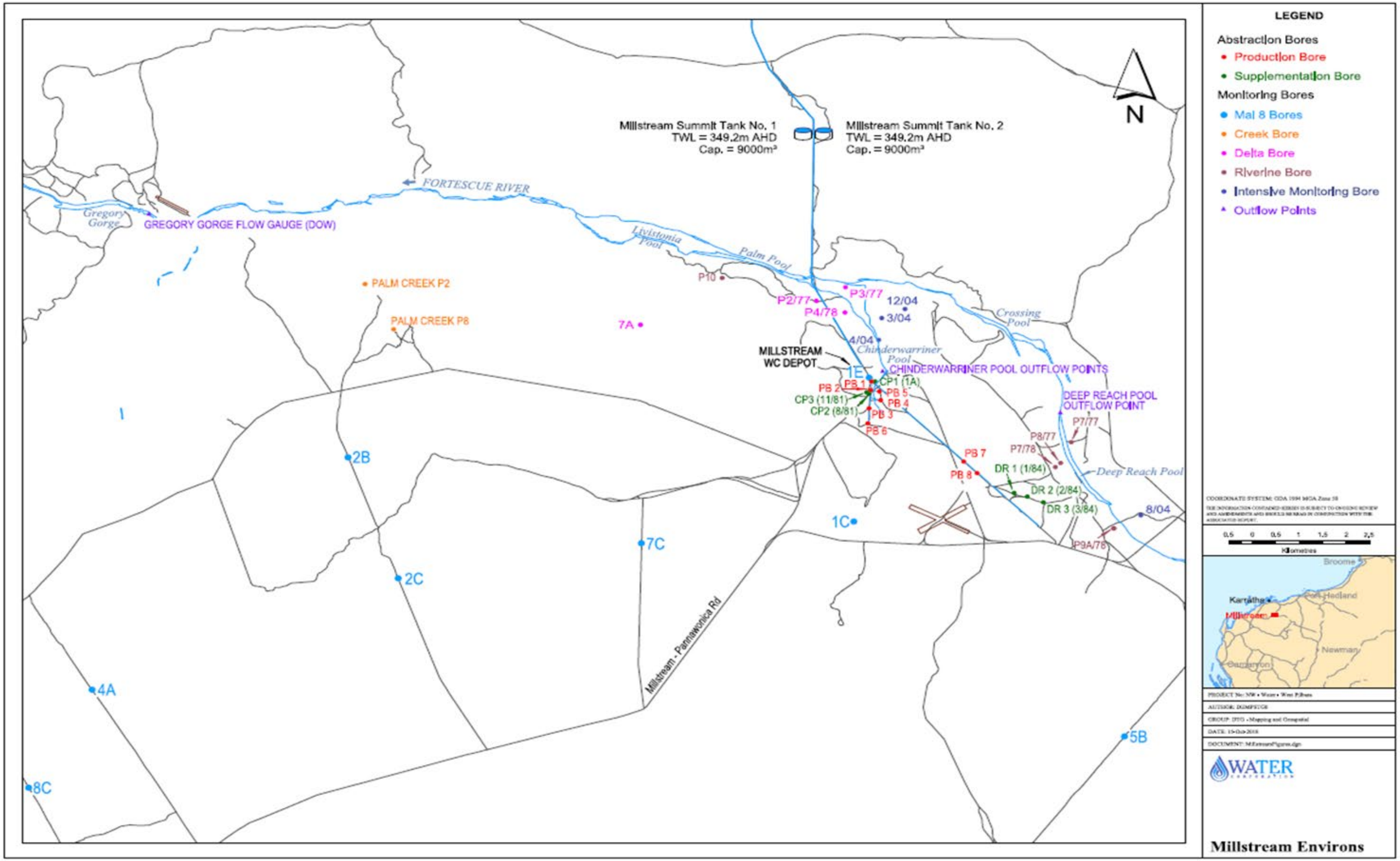


Figure 1.3 Millstream Environs

2. Climate

Climate data for WPWSS was obtained from the SILO database using Millstream Station No. 5012 (Government of Queensland, 2021). Additional rainfall data is obtained from the Harding Dam rainfall gauge W0026619 and this data is stored in the Water Corporation's ODSS database. The WPWSS experiences an arid type climate with hot, humid summers and warm, dry winters.

Historically, January is the hottest month with an average maximum temperature of 38.6 °C and July is the coldest month with an average minimum temperature of 11.7 °C. For the review period, the hottest and coldest months were January and July, with an average maximum and minimum temperature of 39.6 °C and 11.7 °C respectively.

2.1 Rainfall

The long-term average rainfall for Millstream Station No. 5012 is 373.7 mm and the average since 1970 is 409.9 mm. Average annual rainfall over the review period was 364.8 mm which is about 2% below the long-term average. Monthly and annual rainfall for the review period is presented in Table 2.1. Figure 2.1 shows the historical rainfall recorded at Millstream Station No. 5012 since 1992.

Table 2.1 Millstream Station No. 5012 monthly and annual rainfall (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Calendar Year Annual Total	Water Year Annual Total
2018					0.0	80.7	0.0	0.0	0.0	0.0	0.1	0.0		
2019	36.1	0.0	86.4	35.7	0.0	20.8	0.0	0.1	0.0	0.7	0.0	47.6	227.4	239.0
2020	38.2	263.2	19.6	0.0	20.8	0.0	8.4	6.8	0.0	0.2	55.4	136.7	549.3	390.2
2021	96.0	37.6	37.4	65.8										465.1

The long-term average rainfall for Harding Dam is 339.7 mm. Average annual rainfall over the review period was 319.6 mm which is about 6% below the long-term average. Monthly and annual rainfall for the review period is presented in Table 2.2. Figure 2.2 shows the historical rainfall recorded at Harding Dam since 1998.

Table 2.2 Harding Dam rain gauge monthly and annual rainfall (mm)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Calendar Year Annual Total	Water Year Annual Total
2018					0.0	55.5	0.0	0.0	0.0	0.0	1.9	0.0		
2019	14.6	12.9	142.8	13.2	0.0	15.6	1.5	0.3	0.0	2.4	0.3	0.0	203.6	240.9
2020	0.0	191.8	3.6	0.0	33.3	0.0	44.8	8.8	0.0	0.0	3.2	111.6	397.1	215.5
2021	41.4	112.7	30.4	116.2										502.4

Consequently, the WPWSS experienced slightly below average rainfall and above average maximum temperatures over the review period.

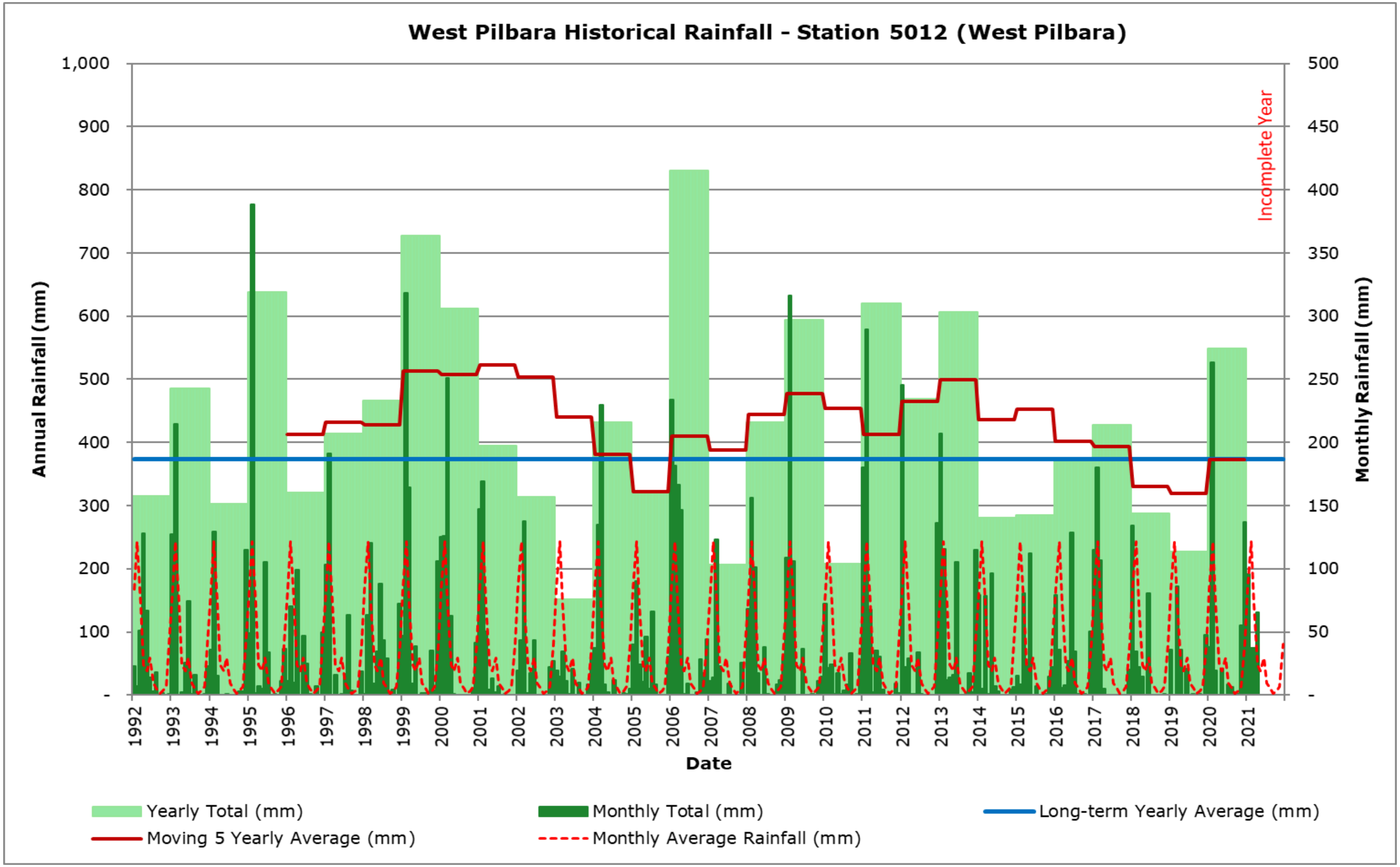


Figure 2.1 Historical Rainfall (mm) for Millstream Station No. 5012

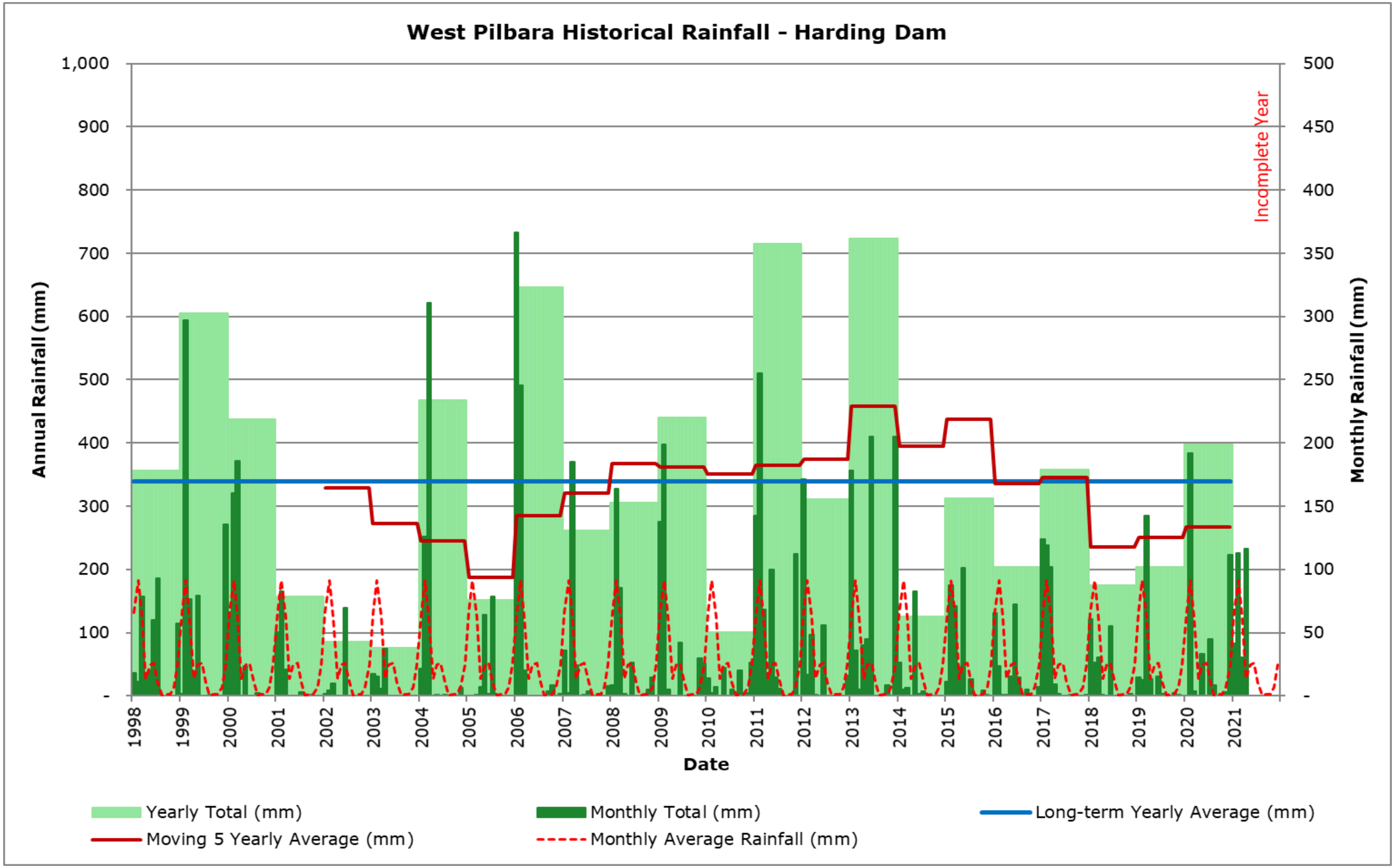


Figure 2.2 Historical Rainfall (mm) for Harding Dam Rain Gauge

2.2 Streamflow

Streamflow through the Fortescue River provides aquifer recharge to the bores at the Millstream Borefield. Streamflow data is obtained from DWER Water Information reporting website using Gregory Gorge gauging station No 708002 (DWER, 2021).

The long-term average streamflow for the Fortescue River during the review period was 181.0 GL, which was about 4% below the long-term average of 187.7 GL (since 1976). Monthly and annual streamflow for the review period is presented in Table 2.3 and historical streamflow since 1991 is shown in Figure 2.3.

Table 2.3 Fortescue River Gregory (DWER Station No 708002) monthly and annual streamflow (GL)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Calendar Year Annual Total	Water Year Annual Total
2018					0.0	5.9	1.5	1.3	0.6	0.0	0.0	0.0		
2019	0.2	0.1	1.5	0.9	0.5	0.7	1.0	0.8	0.3	0.0	0.0	0.9	6.8	12.0
2020	1.6	276.9	1.7	0.5	0.5	0.0	0.7	0.6	0.0	0.0	1.7	27.1	311.2	284.7
2021	2.5	180.6	6.8	25.7										246.3

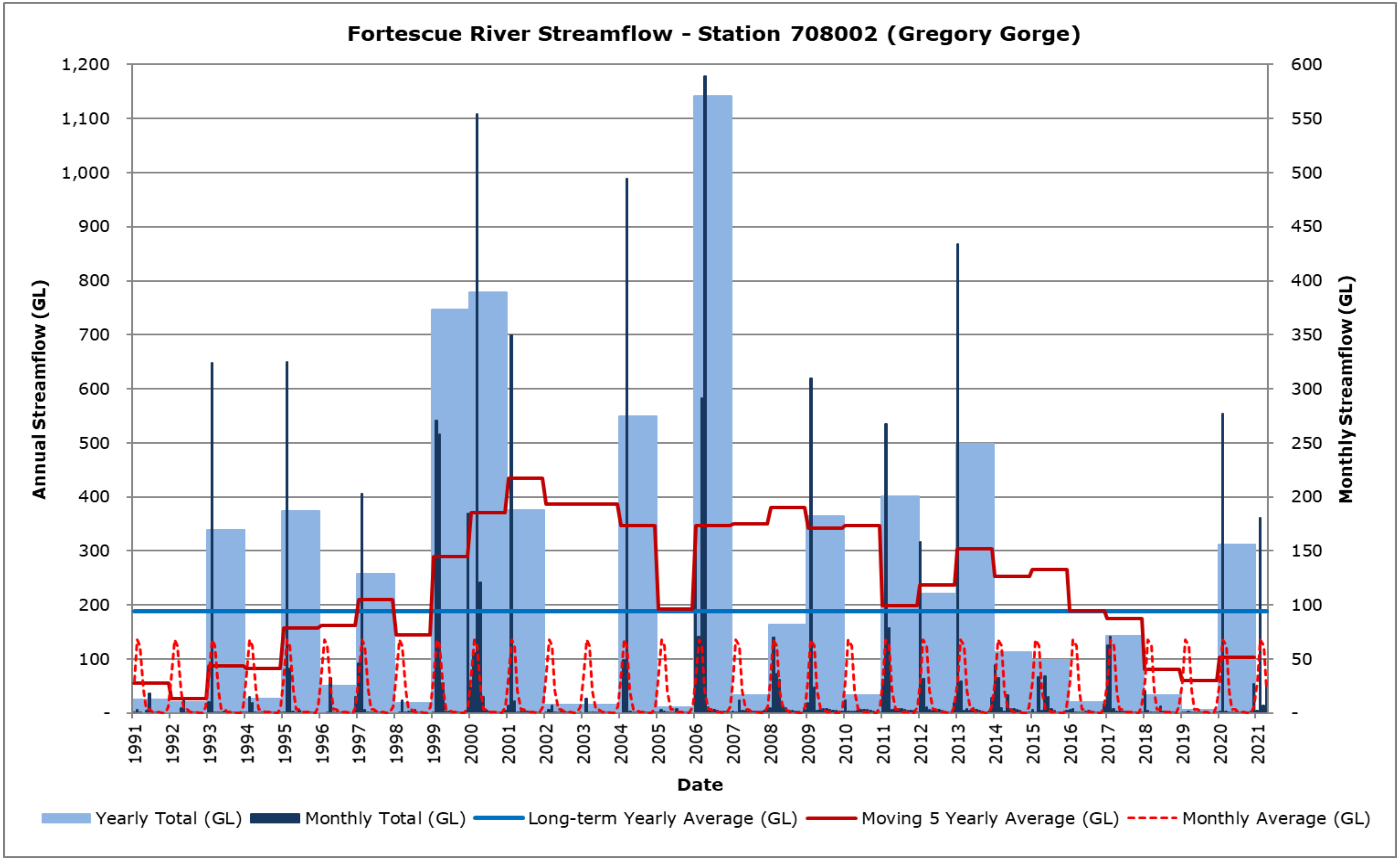


Figure 2.3 Fortescue River Historical Streamflow (GL)

3. Physical Setting

The following information was obtained from the West Pilbara WRMOS (Water Corporation, 2014).

3.1 Millstream Geology

The Millstream aquifer is formed from a succession of Cainozoic alluvial, colluvial and lacustrine sediments of which calcrete (dolomite), with well-developed solution cavities, is the major aquifer (Barnett and Commander, 1985). The sediments occupy a broad paleovalley between the Hamersley Range and the Chichester Range.

3.2 Millstream Hydrogeology

3.2.1 Groundwater flow and discharge

The regional groundwater flow is from the south-east to north and the average annual fluctuation in water level is about 0.5 m (URS, 2007). To the east of Deep Reach, groundwater flows in the direction of the river; west of Deep Reach Pool the groundwater flow direction is predominantly south to north. About 20 km to the south west of Palm Creek a groundwater divide exists, beyond which the groundwater flows south west towards Robe River.

The primary groundwater discharge area from the aquifer is around Deep Reach Pool where the Fortescue River has cut directly into the dolomite. Much smaller quantities of groundwater also discharge from the Millstream dolomite into Chinderwarriner Pool, Woodley Creek, Palm Creek, and Peters Creek where these creek systems have eroded into the edges of the dolomite formation.

Evapotranspiration is a major discharge mechanism from the aquifer and rates of 550 to 3,700 mm/yr have been reported in the Millstream Management Plan (Welker Environmental Consultancy, 1998).

3.2.2 Recharge

Recharge to the Millstream aquifer occurs in the following ways:

1. Infiltration from flood flows in the Fortescue River (upstream of Deep Reach Pool),
2. Direct infiltration of rainfall,
3. Infiltration from runoff via creeks (northern flank of Hamersley Range),
4. Throughflow from the flanking sediments.

Large recharge events typically occur with high river flows. A good example of this is in December 1975 when cyclone Joan passed through the area. No rainfall was recorded in the Millstream area, so the aquifer recharge that occurred (in the order of 50 GL – Barnett and Commander, 1985) was via direct infiltration from river flood flows generated higher up in the catchment. Direct rainfall recharge to the aquifer had been estimated to range from 3 to 16 GL/a (Barnett and Commander, 1985) depending on rainfall location.

3.2.3 Water Quality

The variation in salinity in the Millstream Aquifer is reflective of the type of recharge and discharge mechanisms at work in different parts of the aquifer. Where the Millstream dolomite outcrops and is incised by the Fortescue River (from Deep Reach Pool to 35 km upstream of this point), salinities reach over 1,200 mg/L TDS. It is believed that the elevated salinity levels may be a result of evapotranspiration from vegetation along the banks of the Fortescue River (Welker Environmental Consultancy, 1998), or that the high salinities are due to the recharge of brackish water from the Fortescue River during flood events (Barnett and Commander, 1985). It is likely that a combination of the two processes contribute to the levels observed. Where the Millstream dolomite is overlain by Kangiangi Clay salinities in the dolomite area are generally under 500 mg/L TDS. There is low discharge in this area and recharge occurs by rain filtering around the edge of the clays, through the Robe Pisolite into the underlying dolomite.

3.3 Harding Dam Hydrology

The Harding Dam Catchment covers part of the north-west of the Hamersley Basin and has an area of approximately 1,100 km2. The mean annual inflow in the Harding Catchment has been determined at 54 GL/yr. Rainfall runoff is high due to the intense rainfall events generated by cyclone activity and the relatively impervious nature of the catchment. At full capacity the water level in the dam lies at 60 mAHD resulting in a storage capacity of 63.8 GL and a surface area of 14 km2. The minimum hydraulic operating level is approximately 47 mAHD, which leaves 5 GL storage. However, water quality issues (e.g., high inorganics) typically result in cessation of abstraction with 14 GL storage. Salinity levels in the dam range from 100 to 500 mg/L.

4. Water Resource Management and Allocation

4.1 Allocation and Licensing

The WPWSS is currently operated under two licences; Groundwater Well Licence No. GWL 105696(7) and Surface Water licence No. SWL105715(7); issued under Section 5C of the Rights in Water and Irrigation Act 1914 (RIWI Act) which will expire on the 11/05/2024. The licensed allocation is 15,000,000 kL/year for each individual licence, limited to a combined total draw of 15,000,000 kL/year for both licences. Copies of the licences are contained within Appendix A.

4.2 Groundwater Management

4.2.1 Water Allocation and Availability

Water resource use and conservation in Western Australia is administrated by the Department of Water and Environmental Regulation (DWER) in accordance with the RIWI Act. This Act requires a licence to draw water from surface water and groundwater areas proclaimed under the Act throughout the state and from all artesian bores.

In October 2013 the Department of Water published the Pilbara Groundwater Allocation Plan (DOW, 2013). The Hammersley-Millstream aquifer is identified as fully allocated, with 15,000,000 kL/yr for public water supply and 682,500 kL/yr for general licensing. The plan notes that the long-term reliable allocation for Millstream is an average of 6 GL/yr.

4.2.2 Catchment Protection

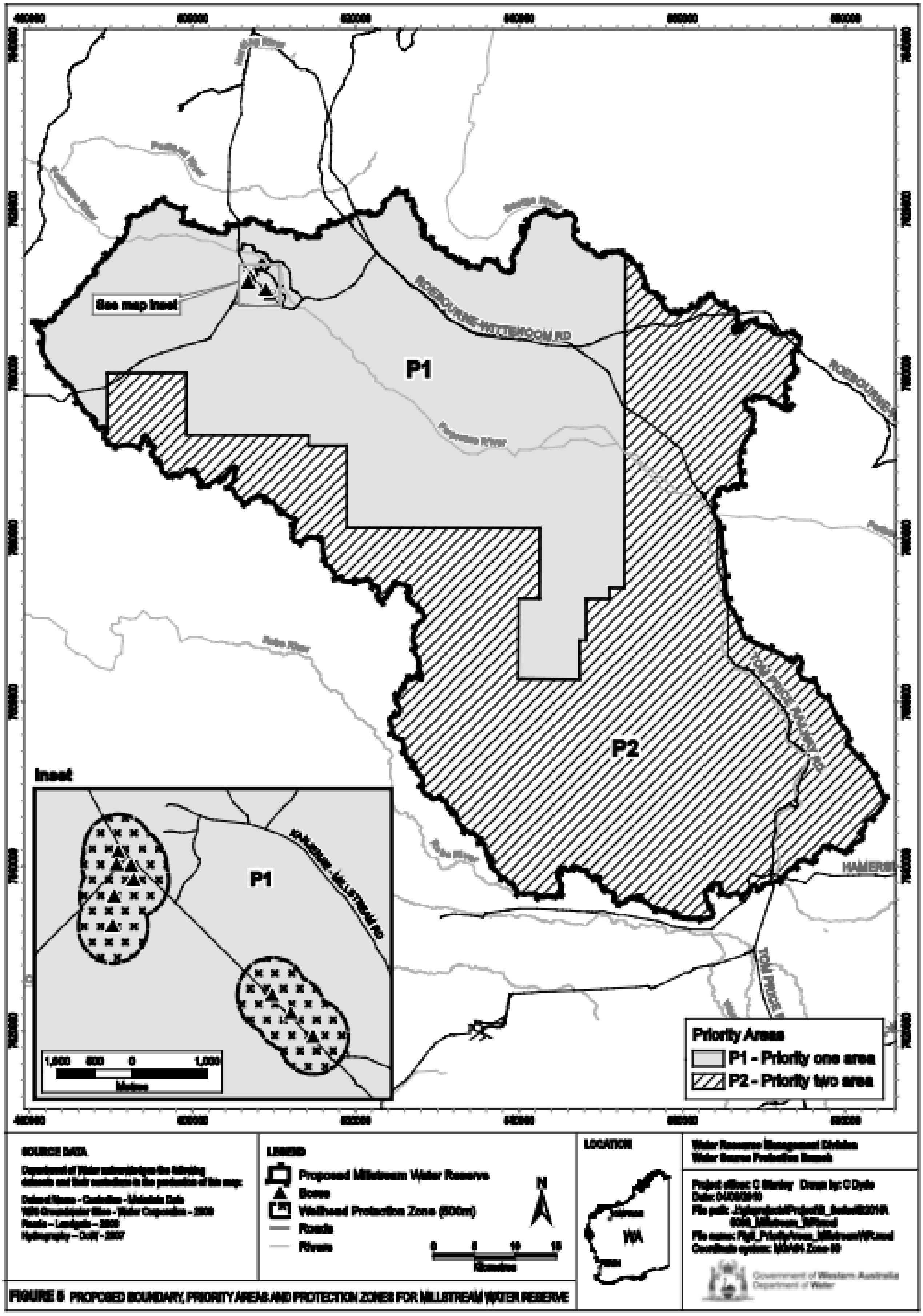
4.2.2.1 Millstream

The Millstream Water Reserve was proclaimed in 1969 under the Country Areas Water Supply Act 1947 (WA) for the purpose of public drinking water source protection. The initial Water Source Protection Plan (WSPP) was gazetted in February 2001. The plan proclaimed protection areas P1 and P2 as shown in Figure 4.1, including the western portion of the Millstream Dolomite outcrop up to the groundwater divide, to ensure areas that contributed recharge to the aquifer were adequately protected.

A new Water Source Protection Plan (SPP) was prepared for Millstream in 2010 (DoW, 2010). This plan confirmed the need to continue protecting the western portion of the dolomite outcrop and recommended that in addition to retaining the current P1 and P2 priority areas, well head protection zones should be proclaimed around each production bore.

4.2.2.2 Harding Dam

A Water Source Protection Plan for Harding Dam was prepared by the Water and Rivers Commission (WRC, 1999). This protection plan recommended the Harding Dam Catchment Area should be proclaimed under the Country Areas Water Supply Act 1947 and the catchment area should be classified for priority 1 source protection, and establishing a reservoir protection zone within a 2 km area around the top water level. The updated boundary for the Harding Dam Catchment Area, as proposed in the 1999 WSPP, was gazetted in January 2001 (Figure 4.2).



*Note that wellhead protection zones are not yet gazetted.

Figure 4.1 Millstream water supply protection priority areas (DoW 2010).

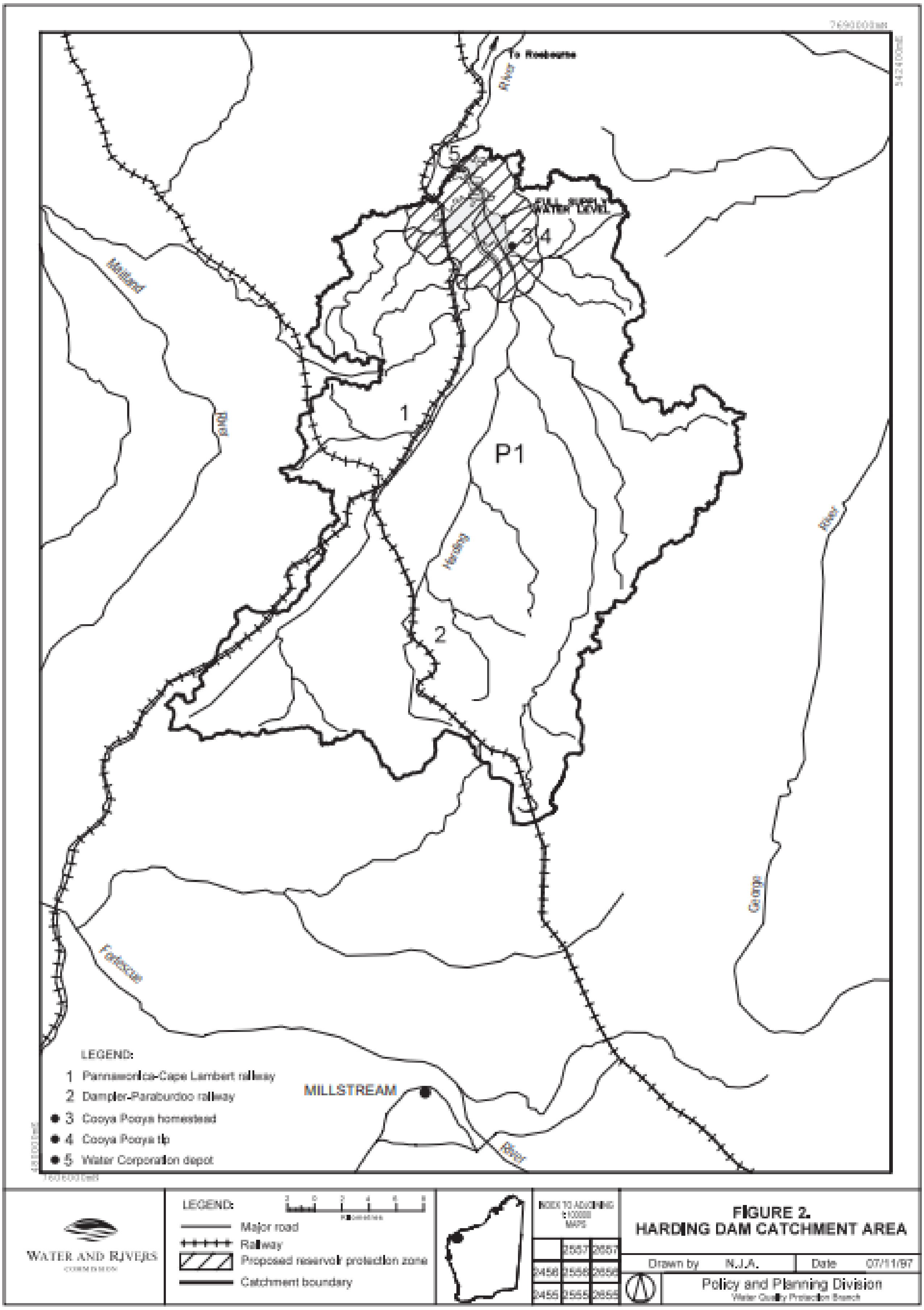


Figure 4.2 Harding Dam water supply protection priority areas (WRC, 1999)

4.3 Water Resource Management Concerns

4.3.1 Demand Pressures

The Water Corporation's Asset Performance and Forecasting Group have provided data on population and service growth for the WPWS scheme using population data from Forecast.id.com.au. Between 2020 and 2050, the average water services population growth in the WPWSS is forecast at 2.4% per year.

4.3.2 Potential Water Quality Risks

Millstream

The Millstream water source protection plan (DoW, 2010) identifies a number of potential water quality risks. The primary risks relate to:

- Pathogen risks from National Park visitor facilities, DCS camp, DEC depot and rangers' quarters located near the old Millstream homestead. All facilities have wastewater treatment systems.
- Bulk fuel storage and pathogen risk from staff facilities at Water Corporation's depot.
- Chemical leachate from DEC and Water Corporation rubbish tip and disused Millstream Station rubbish tip.

There are a number of pastoral leases and mining tenements within the Millstream Water Reserve. These are unlikely to pose a significant threat to water quality, as pastoral leases are located well away from the borefield and the mining tenements are currently inactive. Water Corporation monitoring of raw water quality since 2005 has found no occurrences of health-related chemical or microbiological contamination exceeding ADWG guidelines.

Harding Dam

The Harding Dam water source protection plan (WRC, 1999) identifies a number of potential water quality risks. The primary risks relate to:

- Pathogen risks arising from recreational use of the dam catchment.
- Diesel spill from nearby Pannawonica-Cape Lambert and Dampier-Paraburdoo railways.
- Water quality issues associated with large inflows, seasonal destratification and reservoir turnover. Issues include turbidity, iron, manganese, phytoplankton and cyano-bacteria.

Preventative measures are in place to manage recreational use and reduce the risk of train derailment within the catchment. Seasonal water quality issues are managed through water treatment or use of alternate supply from Millstream and Bungaroo. Water Corporation monitoring of treated water quality since 2007 has found no occurrences of health-related chemical or microbiological contamination exceeding ADWG guidelines.

4.3.3 Groundwater Dependent Ecosystems (GDE's) and Wetlands

Groundwater Dependent Ecosystems (GDEs) can be defined as complex communities of organisms where groundwater is a critical element required for consumptive use, biophysical processes or as habitat. GDEs are permanently or periodically dependent on the prevailing groundwater regime, including terrestrial vegetation and fauna, river base flow systems, aquifer cave ecosystems, wetlands and estuarine or near shore marine systems.

Millstream

The Millstream borefield is situated in an area recognised for its environmental value. The natural pools and surrounding riverine ecosystems at Millstream have been identified as groundwater dependant ecosystems (GDEs) reliant on water from the Millstream Aquifer. The Millstream wetland system comprises approximately 20 km of the Fortescue River and its tributaries. The Millstream National Park, which encompasses this area, is listed on the Register of the National Estate and in the Directory of Important Wetlands of Australia. It includes four major permanent river pools (Deep Reach, Crossing, Livistonia and Palm Pools), interconnected by permanent flowing channels, spring-fed pools on tributaries (eg Chinderwarriner Pool) and large areas of riparian and wetland vegetation (DoW Millstream status report 2009).

Environmental water requirements (EWRs) for Millstream specified in the Pilbara Water Allocation Plan (DoW, 2013) include:

- minimum groundwater levels to ensure the water table does not drop below the root depth of groundwater-dependent vegetation and
- minimum spring discharge from the aquifer, to ensure the environmental demand of the downstream environment is met.

These environmental criteria aim to protect the environmental health when the aquifer levels are low. When the aquifer levels are high, outflows from the aquifer are more than sufficient to meet the environmental water requirements.

Harding Dam

During 1997 and 1998 Streamtec Pty Ltd investigated the Environmental Water Requirements (EWRs) for the Harding River downstream of the Harding Dam (Streamtec, 2002). The study concluded that Pinannular and Waranoolar Pools, where riparian vegetation values were deemed to be of significance, are key environmental areas downstream of the dam. This research also concluded that water quality, and in particular dissolved oxygen, was the major determinant of biodiversity in the downstream pools and recommended a minimum groundwater level to trigger the release of dam water to supplement Pinannular Pool.

A trial release conducted during the summer of 2001/2002 showed there was a strong but transitory link between surface water and groundwater levels and maintaining elevated groundwater levels would require substantial and continuous river flows.

There was a prescribed environmental water release in 2020 from January 3 to January 16 due to the water level of monitoring bore 5/81 going below its trigger level.

5. Compliance

5.1 Millstream Monitoring Program

The current monitoring program is set out in the 2014 West Pilbara Water Resource Management Operation Strategy (WRMOS, 2014). The monitoring requirements are set out below in Table 5.1.

Table 5.1 Monitoring program (Millstream)

Frequency	**Requirement** [#3]
Millstream Aquifer Monitoring Program	
Every month *or annually in November if the bore is not in operation since the start of the water year*	• Production bore water rest levels, abstraction and conductivity [#1 #2] (as TDS mg/L and all samples tested in the lab) Millstream Production bores (equipped) – PB1, PB2, PB3, PB4, PB5, PB6
Every month	Water rest levels in bores PB7, PB8
Before use	• Deep Reach and Chinderwarriner Supplementation bore conductivity (TDS mg/L and all samples tested in the lab) and report to DWER Deep Reach supplementation bores – DR1(1/84), DR2(2/84), DR3(3/84) Chinderwarriner supplementation bores – CP1(1A), CP2(8/81), CP3(11/81)
Every month when in use	• Deep Reach and Chinderwarriner Supplementation bore water rest levels, bore abstraction and conductivity (TDS mg/L and all samples tested in the lab) Deep Reach supplementation bores – DR1(1/84), DR2(2/84), DR3(3/84) Chinderwarriner supplementation bores – CP1(1A), CP2(8/81), CP3(11/81)
Every 2 months *or frequency to increase to monthly when MAL below 293.8 m AHD*	• Water rest levels in monitoring bores MAL8 bores – 1C, 1E, 2B, 2C, 4A, 5B, 7C, 8C • Water rest levels in monitoring bore 7A, PB7, PB8
Annually	• All production bores (equipped) water quality major components [#4] • Conductivity – PB7, PB8
Annually *when not in use*	Deep Reach and Chinderwarriner Supplementation bore water rest levels and bore abstraction
Millstream Delta	
Every 2 months	Chinderwarriner Pool – Salinity as TDS and outflow (kL/s) *Frequency of above pool outflow monitoring to increase to fortnightly when triggered by Management Framework* [#6]
	Water rest levels - monitoring bores P2/77, P3/77, P4/78, 03/04, 12/04, 04/04 *Frequency to increase to monthly when triggered by the Management Framework*

Frequency	Requirement #3
Creeks	
Every 2 months	Peters, Woodley and Palm Creeks outflow rate (kL/s)
	Water rest levels in monitoring bores P2, P8
Riverine Area	
Every 2 months	Deep Reach Pool – water quality (TDS) and outflow rate (kL/s) *Frequency of above pool outflow monitoring to increase to fortnightly when triggered by the Management Framework #6*
	Water rest levels in monitoring bores P8/77, P7/78, 08/04, P10 (DoW bore), P7/77, P9A/78 *Frequency to increase to monthly when triggered by the Management Framework*
Climate (BoM Station 5012)	
Daily	Rainfall and pan evaporation
Millstream Environ - vegetation	
Annually in November	The Millstream environmental monitoring program will be implemented by a joint venture between the Corporation, DPaW, and DWER as detailed in WRMOS (Appendix D). The DWER will report on the program annually at the MHCC meeting. This report will include a summary of the previous years' budgets and a forecast of the coming years' budget. Additional costs above those detailed in Appendix D will be subject to agreement from the Corporation.

Notes

#1 DoW have set a performance indicator to maintain water quality, as an average across equipped bores, below 900 mg/L TDS.

#2 Temperature measurement is required if a conductivity at 25ºC measurement is not taken.

#3 Any new or replacement production bore will be subjected to the same monitoring requirements as existing production bores.

#4 Results of all major component analysis to be presented in Water Monitoring Review.

#5 Every effort will be made to ensure monitoring occurs in the nominated month. Should there be an unforeseen event preventing readings being taken, the Water Corporation will resume monitoring as soon as practical.

#6 Any changes from the baseline pool outflow monitoring frequency will occur after consultation with the technical working group. Final discretion rests with DWER and will be made after DWER's consideration of the cost-benefit of additional monitoring.

Compliance is assessed by taking into account the reason for any missed monitoring and whether DWER were notified of the missed monitoring.

Missed monitoring is categorised as controllable or uncontrollable. Specific definitions for controllable and uncontrollable misses are provided in the Water Corporation's Management of Non-compliances and Breaches procedure (#9092803) and are summarised as:

- A controllable miss is defined as missed monitoring or sampling (required by the scheme WRMOS, licence or permit) that could have been taken with reasonable preparation, planning and performance of employees.

- An uncontrollable miss is defined as missed monitoring or sampling (required by the scheme WRMOS, licence or permit) that could not be taken due to an unforeseen event, due to compromised safety or access or due to equipment failure or planned maintenance when:

    - there is no alternative method for sampling (i.e. tape reading) at the bore,
    - there is no opportunity to reschedule within the one-week sampling tolerance period; and
    - the repairs are being carried out within the agreed timeframes.

Uncontrollable misses may change classification to controllable, when no action is taken to reinstate the monitoring within the standard or agreed timeframe AND no action has been made to communicate with DWER to agree a revised timeframe. This allows for extension to the agreed timeframe by prior agreement with DWER.

Compliance with the required monitoring program for the review period is shown in Tables 5.2 and 5.3 and has followed the required frequency set out in the WRMOS, with the exception of the following:

<u>2018/2019</u>

- All Millstream Production bores, MAL8 bores and Bores 7A, PB7 and PB8 missed water level readings in March 2019 due to the weather conditions (Cyclone Veronica),
- Production bores 2, 3, and 6 missed conductivity readings due to bores being out of service,
- Production bores 7 and 8 missed conductivity readings as pump and headworks have been removed.

<u>2019/2020</u>

- Production Bore 1 missed a conductivity reading in April 2020 due to an oil leakage.
- Production Bore 2 missed a conductivity reading in in August 2019 due to a start fault in the engine.
- Production Bore 4 missed a conductivity reading in December 2019 and January 2020 due to the diesel engine radiator being removed for repair.
- Both standby production Bores 7 and 8 missed annual conductivity readings because the bores no longer have headworks. A suitable sampling regime has yet to be determined for these large diameter bores.
- Monitoring Bores 8C missed a water level reading in January to February 2020 due to a large rainfall event preventing access.
- Monitoring Bores 7C missed all water level readings for the water year as bore is blocked.
- Monitoring Bores 4A, 8C, 3/04 and 3/77 missed water level readings in March to April 2020 due to the access bridge being washed away.
- Bore P7/78 missed water level readings in May to August 2019 due to fibrous root intrusion preventing equipment access.

2020/2021

- Production Bore 1 missed conductivity readings in June and September 2020 due to mechanical issues with the pump.
- Production Bore 4 missed conductivity readings from May to November 2020 due to the bore being offline with engine radiator issues.
- Monitoring Bore 3/04 missed water level readings for the water year as the access bridge to the site had washed away.
- Both standby production Bores 7 and 8 missed conductivity readings for the water year because the bores no longer have headworks and did not run. To undertake accurate sampling a pump and generator will be purchased.
- Monitoring Bore 7C missed water level readings for the water year as the bore was blocked. However, approval from DWER was obtained to obtain readings from nearby monitoring Bore 2/75 in lieu. Bore 7C has recently been redrilled and monitoring of the new bore has commenced.
- Monitoring Bore 8C missed water levels readings from January to April 2021 as the bore was inaccessible due to heavy rainfall. To overcome this issue a project has commenced that will equip the MAL Bores and Bore 7A with hydrostatic probes and telemetry for remote monitoring – projected completion mid 2022.

Table 5.2 Compliance with the monitoring program – Millstream Aquifer

Requirement	**Frequency**	**2018/2019**							**2019/2020**							**2020/2021**						
		Required	**Taken**	**Missed**				**% Compliant**	**Required**	**Taken**	**Missed**				**% Compliant**	**Required**	**Taken**	**Missed**				**% Compliant**
				Uncontrollable	**# notified within timeframe**	**Controllable**	**# notified within timeframe**				**Uncontrollable**	**# notified within timeframe**	**Controllable**	**# notified within timeframe**				**Uncontrollable**	**# notified within timeframe**	**Controllable**	**# notified within timeframe**	
Millstream Aquifer Monitoring Program																						
Production Bores (PB1, PB2, PB3, PB4, PB5, PB6)																						
Abstraction	Monthly when in use (from Apr-14)	72	72	0	0	0	0	100	72	72	0	0	0	0	100	72	72	0	0	0	0	100
Water level	Monthly when in use (from Apr-14)	72	66	6	6	0	0	100	72	72	0	0	0	0	100	72	72	0	0	0	0	100
Conductivity	Monthly when in use	72	57	15	15	0	0	100	72	68	4	4	0	0	100	72	63	9	9	0	0	100
Major Analysis	Annually	6	5	1	1	0	0	100	6	6	0	0	0	0	100	6	6	0	0	0	0	100
Production Bores (PB7 and PB8)																						
Water level	Monthly	24	22	2	2	0	0	100	24	24	0	0	0	0	100	24	24	0	0	0	0	100
Conductivity	Annually	2	0	2	2	0	0	100	2	0	2	2	0	0	100	2	0	2	2	0	0	100
Supplementation Bores (CP1, CP2, CP3, DR1, DR2, DR3)																						
Abstraction (if in use)	Monthly when in use	N/A - not in use							N/A - not in use						100	N/A - not in use						100
Water level	Monthly when in use	N/A - not in use							N/A - not in use						100	N/A - not in use						100
Water level	Annually when not in use	6	6	0	0	0	0	100	6	6	0	0	0	0	100	6	0	6	6	0	0	100
Conductivity (if in use)	Monthly when in use	N/A - not in use							N/A - not in use						100	N/A - not in use						100
Mean Aquifer Level and Bore 7A																						
Water level - MAL8 bores (1C, 1E, 2B, 2C, 4A, 5B, 7C, 8C) and 7A	Every 2 months or monthly when triggered	54	45	9	9	0	0	100	48	39	9	9	0	0	100	48	40	8	8	0	0	100

Table 5.3 Compliance with the monitoring program – Millstream Environs

Requirement	Frequency	2018/2019							2019/2020							2020/2021						
				Missed							Missed							Missed				
		Required	Taken	Uncontrollable	# notified within timeframe	Controllable	# notified within timeframe	% Compliant	Required	Taken	Uncontrollable	# notified within timeframe	Controllable	# notified within timeframe	% Compliant	Required	Taken	Uncontrollable	# notified within timeframe	Controllable	# notified within timeframe	% Compliant
Millstream Environ Monitoring Program																						
Delta																						
Chinderwarriner Pool outflow rate	*Every 2 months or fortnightly when triggered*	6	5	0	0	0	0	83	6	6	0	0	0	0	100	6	6	0	0	0	0	100
Chinderwarriner Pool salinity	Every 2 months	6	6	0	0	0	0	100	6	6	0	0	0	0	100	6	6	0	0	0	0	100
Water level (P2/77, P3/77, P4/78, 03/04, 04/04, 12/04)	*Every 2 months or fortnightly when triggered*	36	36	0	0	0	0	100	36	34	2	2	0	0	100	36	30	6	6	0	0	100
Creeks																						
Creek outflow rates (Palm, Peters and Woodley Creek)	Every 2 months	18	18	0	0	0	0	100	18	18	0	0	0	0	100	18	18	0	0	0	0	100
Water level (P2, P8)	Every 2 months	12	12	0	0	0	0	100	12	12	0	0	0	0	100	12	12	0	0	0	0	100
Riverine																						
Deep Reach Pool outflow rate	*Every 2 months or fortnightly when triggered*	6	6	0	0	0	0	100	6	6	0	0	0	0	100	6	6	0	0	0	0	100
Deep Reach Pool salinity	Every 2 months	6	6	0	0	0	0	100	6	6	0	0	0	0	100	6	6	0	0	0	0	100
Water level (P8/77, P7/78, P9A/78, P7/77, 08/04, P10)	*Every 2 months or fortnightly when triggered*	36	36	0	0	0	0	100	36	34	2	2	0	0	100	36	36	0	0	0	0	100
Other Monitoring																						
Rainfall and evaporation	Daily	Collected by BOM							Collected by BOM							Collected by BOM						
Vegetation	Annually	0	0	0	0	0	0	100	0	0	0	0	0	0	100	0	0	0	0	0	0	100

5.2 Harding Dam Monitoring Program

The current monitoring program is set out in the 2014 West Pilbara Water Resource Management Operation Strategy (WRMOS). The monitoring requirements are set out below in Table 5.4.

Table 5.4 Harding Dam Monitoring Program

Frequency	Requirement
Harding Dam Monitoring Program	
Daily	• Reservoir water level
	• Scour valve discharge to Recreation Pool (Records of opening and closing of valve. Metred volume of discharge not required)
	• Rainfall (Water Corporation Harding Dam rainfall gauging station)
Every month	• Abstraction
	• Basic reservoir water quality components sampled from the water treatment plant raw water (pH, cond., turbidity and colour) #1
	• Supernatant discharge to Recreation Pool (Metered volume not required. Only provide estimated as 5% of inflow into water treatment plant)
	• Recreational Pool water level
Every 6 months	• Reservoir water quality major components
	• Supernatant discharge water quality major components (Measured at discharge point at Recreational Pool, not supernatant discharge itself as this is via a sealed underground main)
Harding Dam Environ Monitoring Program	
Every 2 months	• Water level - Pinannular and Waranoolar Pools (derived from monitoring bores 1/00, 2/00 and 3/00)
	• Water rest levels - monitoring bores DSE1/81, DSE2/81, DSE3/81, DSE4/81, DSE5/81#2, DSE6/81

Notes

#1 Frequency reduced from weekly to monthly since commissioning of microfiltration treatment plant.

#2 The Water Corporation will continue to monitor groundwater and pool water levels and report groundwater levels in Bore 5/81 against the trigger of 32.5 mAHD. If this trigger is reached the Corporation in consultation with the technical working group will determine if any action is required.

Compliance with the required monitoring program for the review period is shown in Table 5.5 and has followed the required frequency set out in the WRMOS, with the exception of the following:

2018/2019

- Water level readings for Bore 1/00 was missed in April 2019 due to blockage in bore,
- Basic reservoir water quality missed in May 2018 due to there being no flow at the monitoring point as dam was offline during the later part of the month when monitoring was scheduled,
- Recreational Pool water level missed in May 2018.

2019/2020

- Basic reservoir water quality components sampling was missed in October 2019 due to the dam being shut down for planned maintenance,
- Monitoring bore 1/00 had a missed bi-monthly water level reading in June 2019 as the bore was blocked.

2020/2021

- Bore 2/81 could not be accessed for water level readings January to April 2021 due to wet/muddy conditions,
- Bores 3/81 and 4/81 missed water level readings in April 2021 as the bores could not be accessed due to heavy rainfall.

Table 5.5 Summary of compliance with monitoring program – Harding Dam

Requirement	Frequency	2018/2019							2019/2020							2020/2021						
				Missed							Missed							Missed				
		Required	Taken	Uncontrollable	# notified within timeframe	Controllable	# notified within timeframe	% Compliant	Required	Taken	Uncontrollable	# notified within timeframe	Controllable	# notified within timeframe	% Compliant	Required	Taken	Uncontrollable	# notified within timeframe	Controllable	# notified within timeframe	% Compliant
Harding Dam Monitoring Program																						
Reservoir																						
Abstraction	Monthly	12	12	0	0	0	0	100	12	12	0	0	0	0	100	12	12	0	0	0	0	100
Reservoir water level	Daily	365	365	0	0	0	0	100	365	365	0	0	0	0	100	365	365	0	0	0	0	100
Rainfall	Daily	365	365	0	0	0	0	100	365	365	0	0	0	0	100	365	365	0	0	0	0	100
Basic reservoir water quality components sampled from the water treatment plant raw water (pH, cond., turbidity and colour)	Monthly	12	11	1	1	0	0	0	12	11	1	1	0	0	100	12	12	0	0	0	0	100
Reservoir water quality major components	Every 6 months	2	2	0	0	0	0	100	2	2	0	0	0	0	100	2	2	0	0	0	0	100
Recreational Pool																						
Recreational Pool water level	Monthly	12	11	1	1	0	0	100	12	12	0	0	0	0	100	12	12	0	0	0	0	100
Scour valve discharge to Recreation Pool	Daily (records of opening and closing of the valve)	365	365	0	0	0	0	100	NA	5	0	0	0	0	100	NA	9	0	0	0	0	100
Supernatant discharge to Recreation Pool	Monthly	12	12	0	0	0	0	100	12	12	0	0	0	0	100	12	12	0	0	0	0	100
Supernatant discharge water quality major components	Every 6 months	2	2	0	0	0	0	100	2	2	0	0	0	0	100	2	2	0	0	0	0	100

Harding Dam Environ Monitoring Program																						
Water level - Pinannular and Waranoolar Pools (derived from monitoring bores 1/00, 2/00 and 3/00)	Every 2 months	18	17	1	1	0	0	100	18	17	1	1	0	0	100	18	18	0	0	0	0	100
Water rest levels - monitoring bores DSE1/81, DSE2/81, DSE3/81, DSE4/81, DSE5/81*, DSE6/81	Every 2 months	36	36	0	0	0	0	100	36	36	0	0	0	0	100	36	32	4	4	0	0	100

5.3 Contingency Planning

No contingency plans were enacted during the review period.

5.4 Meter Change Details

No meter changes occurred at any draw point within the scheme over the reporting period.

5.5 Water Use Efficiency

Abstraction and usage data are summarised in Table 5.6 and were obtained from the SAP BW and ODSS databases.

In early 2014 the Corporation revised the definitions and calculation of water losses to better align with the National Performance Framework. Unbilled Authorised Consumption includes water required for the operation of a water treatment plant and planned maintenance of the reticulation, such as scouring. Water losses include leaks and bursts, unauthorised consumption and customer metering errors. Detailed definitions and calculations are provided in the definitions section of this WMS.

Water loss is determined by the following calculation.

$$\left(\frac{\text{Total Abstraction - Volume of water supplied (Residential and Non Residential) - Unbilled Authorised Consumption}}{\text{Total Abstraction}}\right)\times 100$$

Unbilled authorised consumption during the review period ranged from 1.6% to 2.7% of total abstraction. This consumption includes the default value of 0.5%, estimated losses through the Harding Dam treatment plant and from mains scouring.

Water loss for the review period ranged from 14.2% to 17.3%. In the last year it was 15.6%, which is higher than the Water Corporation's target of 15% and higher than the water loss for the previous water year of 14.2%.

Annual residential consumption per unit for the review period ranged from 412 to 428 kL, averaged 419 kL and is lower than the previous review period average of 432 kL.

The Water Corporation is continuing to implement its current Statewide programme of promoting efficient use of water, including imposing rostered watering days, distributing educational pamphlets, offering water saving advice and presenting media campaigns such as 'Water Week' and being 'Water Wise'.

Table 5.6 Abstraction and usage data for review period

Water Year	Total Abstraction	Water Supplied from Bungaroo	Residential and Non-Residential			Unbilled Authorised Consumption [1]		Water Losses [2] (target <15%)		Residential only		
			Volume supplied	Total Connected Properties	Average Annual	Volume	Percentage	Volume	Percentage	Volume Supplied – Residential	Connected Residential Properties – Water Supply	Average Annual Residential Water Supplied per Unit
	(kL)		(kL)	(No. of units)	(kL/unit/yr)	(kL)	%	(kL)	%	(kL)	(No. of units)	(kL/unit/yr)
2014/15	13,305,961	-	11,350,220	10,205	1,112	82,186	0.6%	1,873,555	14.1%	4,016,703	8,373	480
2015/16	13,849,499	-	12,745,544	10,225	1,247	99,980	0.7%	1,003,975	7.2%	3,822,071	8,433	453
2016/17	13,276,233	-	11,885,077	10,232	1,162	157,680	1.2%	1,233,476	9.3%	3,626,882	8,431	430
2017/18	13,798,498	-	11,490,704	10,209	1,126	422,823	3.1%	1,884,971	13.7%	3,477,393	8,417	413
Review Period												
2018/19	7,389,137	6,773,580	11,335,591	10,204	1,111	376,703	2.7%	2,453,918	17.3%	3,510,148	8,409	417
2019/20	7,170,107	7,398,260	12,254,589	10,171	1,205	239,905	1.6%	2,073,873	14.2%	3,449,696	8,372	412
2020/21	7,872,121	6,503,424	11,752,906	10,233	1,149	377,936	2.6%	2,244,703	15.6%	3,572,499	8,341	428

Notes:

1. Unbilled Authorised Consumption was previously described as the *known* water loss.
2. Water losses are equivalent to Total Abstraction less Volume Supplied to Residential and Non-Residential less Unbilled Authorised Consumption. This was previously reported as *unaccounted water*.
3. Data are correct at the time of this review but may differ slightly to past Annual Statements if errors have been detected and adjustments made.

6. Water Abstraction

6.1 Scheme Conjunctive use

Total abstraction for the whole of West Pilbara for the review period varied from 14,166,212 kL to 14,568,367 kL and totalled 43,110,124 kL, which includes 20,675,264 kL from Rio Tinto's Bungaroo borefield. This was higher than the previous review when total abstraction was 40,924,230 kL.

6.2 Scheme Abstraction

The licensed allocation for both sources and the annual abstraction for the review period are given in Table 6.1. Figure 6.1 graphically shows the monthly abstraction for the review period. Total scheme abstraction has ranged between 7,170,107 kL and 7,872,121 kL over the review period.

Total abstraction for the Millstream borefield during the review period was 11,739,546 kL. This was considerably lower than the borefield's total abstraction for the previous review of 16,204,921 kL.

Abstraction for Harding Dam during the review period totalled 10,695,314 kL. During 2019/20, Harding Dam had been offline for a substantial part of the year due to dam maintenance and declining water capacity. The dam was online for the majority of the 2020/21 water year and reliance on Millstream was greatly reduced.

Monthly abstraction data are detailed in Appendix C.

Table 6.1 Total annual scheme abstraction (kL)

Source	Licence No.	Licence Allocation (kL)	2018/19 Abstraction (kL)	2019/20 Abstraction (kL)	2020/21 Abstraction (kL)
Millstream	GWL105696	15,000,000*	2,559,757	5,628,841	3,550,948
Harding Dam	SWL105715	15,000,000*	4,832,875	1,541,266	4,321,173
Total (kL)		15,000,000	7,392,632	7,170,107	7,872,121

* Annual combined draw (including any supplementation) is not to exceed 15,000,000 kL.

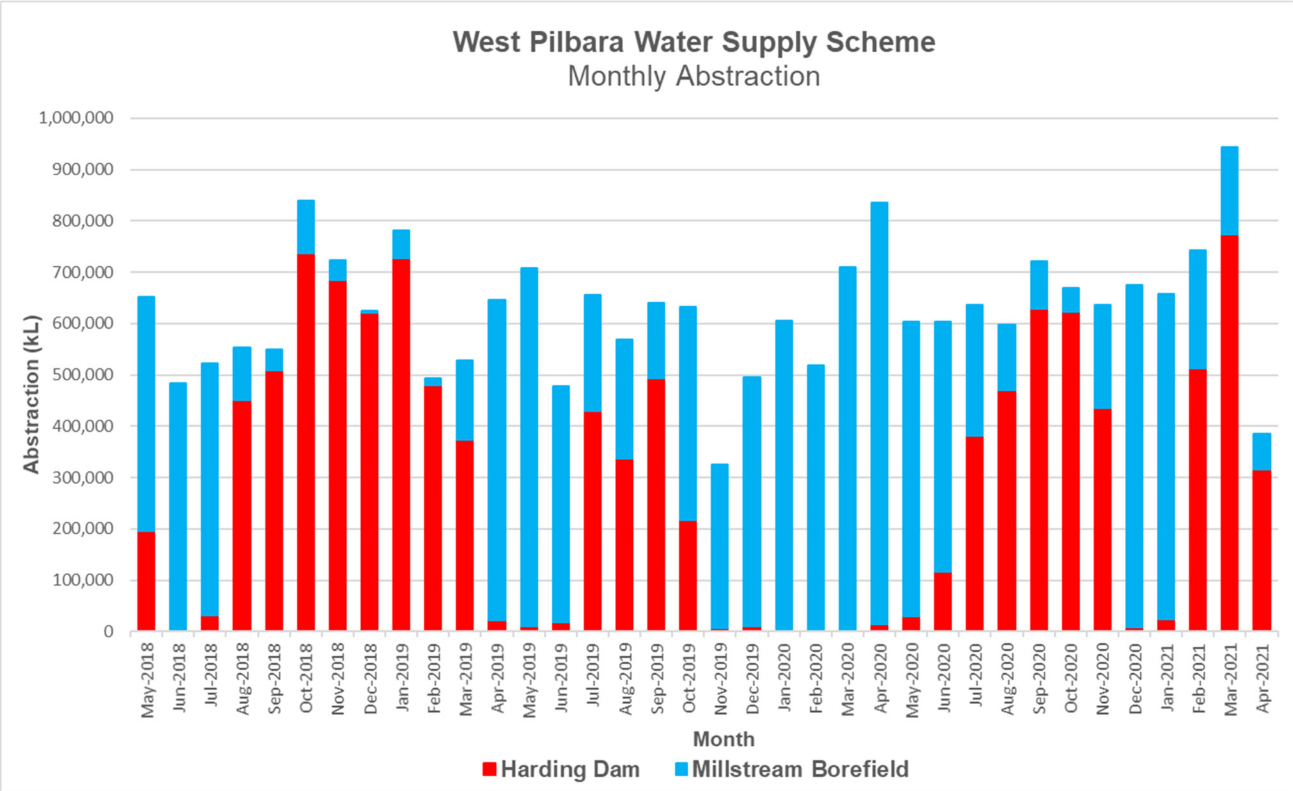


Figure 6.1 Total annual abstraction

The annual abstraction for the production bores at Millstream for the review period is given in Table 6.2. Figures 6.2 and 6.3 graphically presents the monthly abstraction by the Millstream borefield and Harding Dam. Monthly abstraction data are detailed in Appendix C.

Table 6.2 Total annual abstraction of individual production bores (kL)

Water Year	Millstream Bore 1 (kL)	Millstream Bore 2 (kL)	Millstream Bore 3 (kL)	Millstream Bore 4 (kL)	Millstream Bore 5 (kL)	Millstream Bore 6 (kL)	Annual Total (kL)
2018/19	719,000	422,218	495,716	424,738	448,235	49,850	2,559,757
2019/20	1,032,775	1,228,120	663,174	883,204	1,087,819	733,749	5,628,841
2020/21	241,920	349,438	1,229,491	295,171	822,664	612,264	3,550,948
Bore Total	1,993,695	1,999,776	2,388,381	1,603,113	2,358,718	1,395,863	11,739,546
% Supplied by bore	17	17	20	14	20	12	100

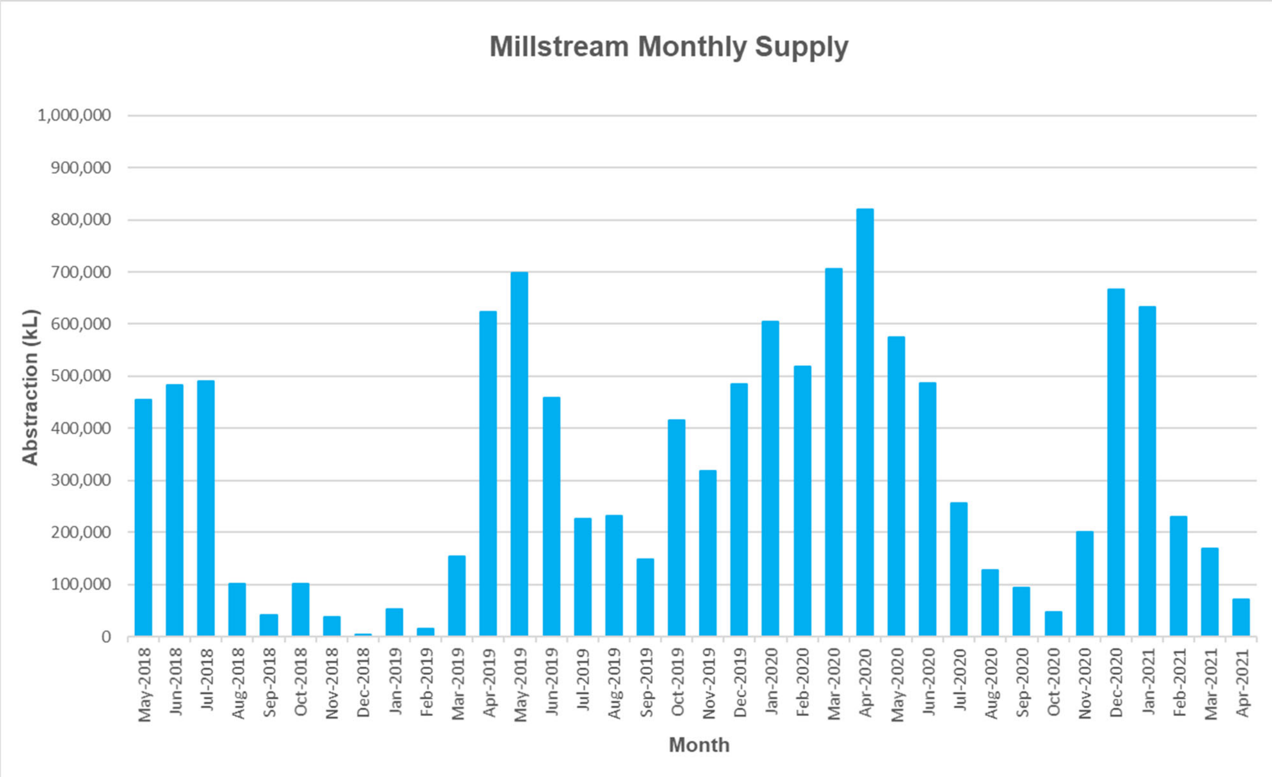


Figure 6.2 Millstream monthly abstraction during the review period

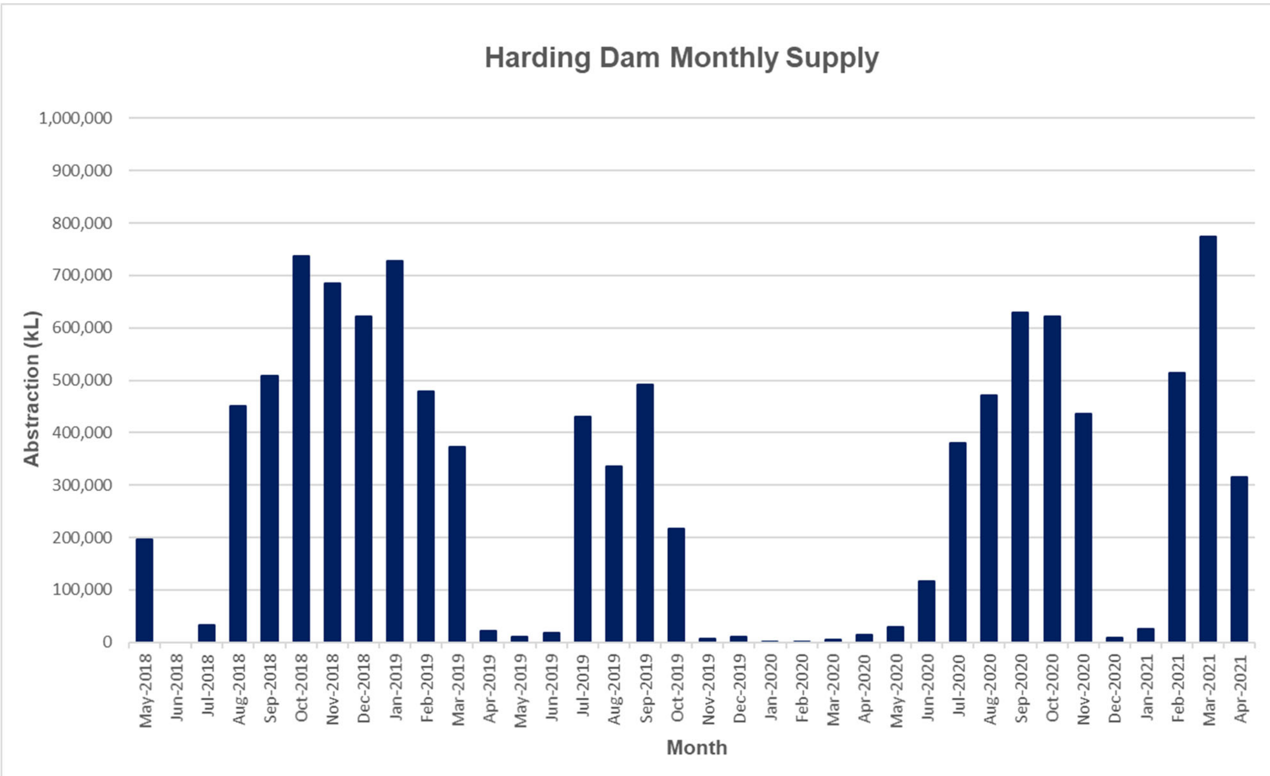


Figure 6.3 Harding Dam monthly abstraction during the review period

6.3 Future Demands for Water

Historical and forecast consumption, abstraction, and number of units are presented in Figure 6.4. An average growth rate in the number of units for the review period was used to predict the growth rate for the next five years. The average water usage per unit and average water losses for the last five years were applied to the number of units to predict consumption and abstraction over the same period.

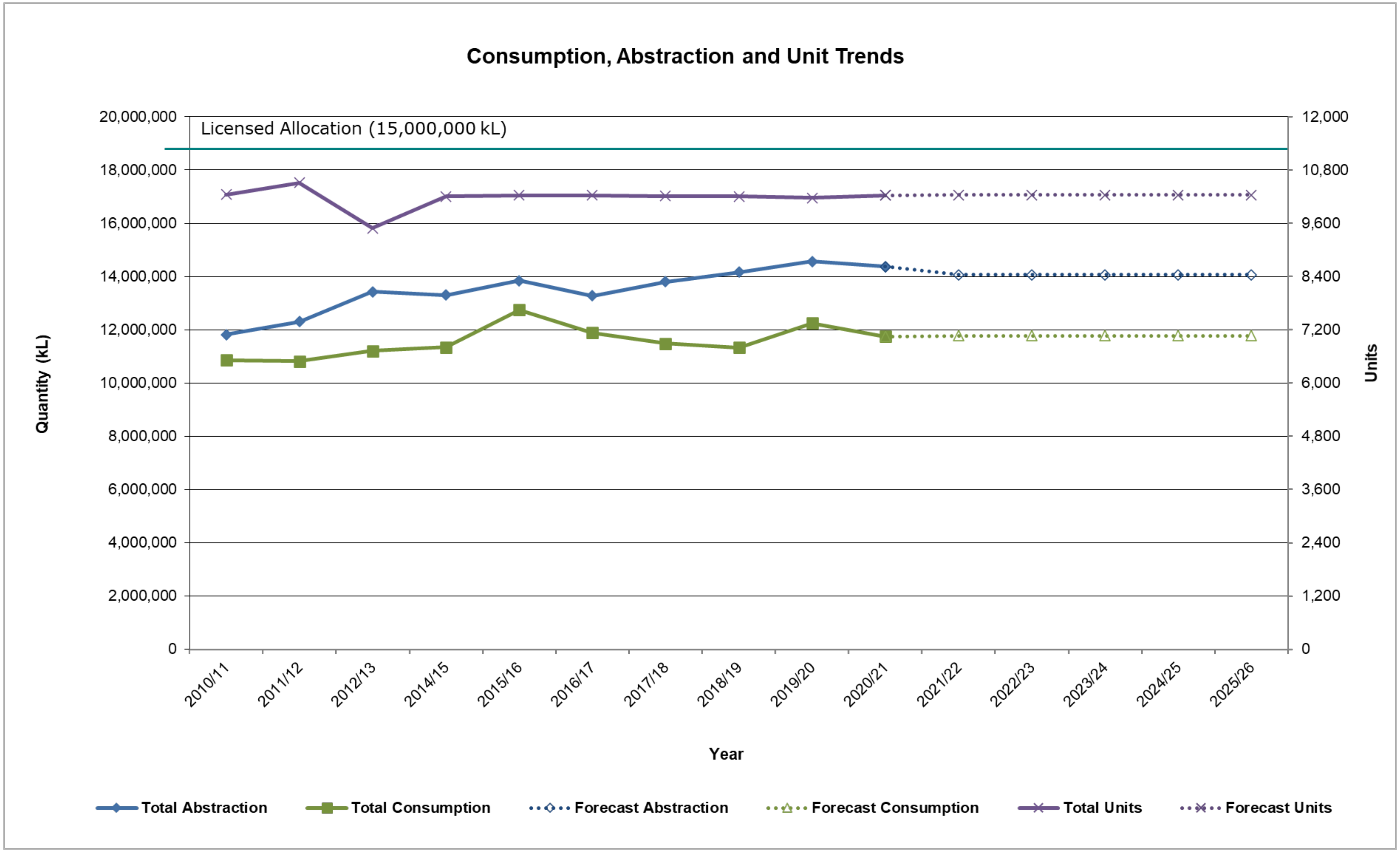


Figure 6.4 Consumption, abstraction and unit trends

7. Monitoring Results

Monitoring required to be undertaken by the Water Corporation is detailed in the West Pilbara WRMOS (Water Corporation, 2014). The water level and salinity data monitored during the review period is presented graphically in Appendices D and E for both production and monitoring bores. A summary of the water quality results obtained during the review period is shown in Appendix F.

7.1 Millstream

7.1.1 Recharge Class

Fortescue River flow at Gregory Gorge is used to determine the year's recharge class and corresponding criteria which will be applied in any given year. The recharge class for the water year is determined each June by agreement between DWER and the Water Corporation based on the previous years' wet season flow. Table 7.1 shows the recharge classes for the past three water years. For the 2020/21 water year a Dry recharge class was assigned even though a high streamflow was observed, as the target MAL of 294.00 mAHD at the beginning of the water year was not reached.

Table 7.1 Recharge class for Millstream

Fortescue River Flow (Wet Season December – April) at Gregory Gorge gauging station			
Year of Flow	**Stream flow (GL)**	**Monitoring Year**	**Recharge Class**
2017/18	23.25	2018/19	2 (Dry)
2018/19	12.04	2019/20	2 (Dry)
2019/20	284.69	2020/21	2 (Dry)*

*Flow >43 GL but target MAL not met

7.1.2 Millstream Production Bore Levels

Hydrographs for the Millstream production bores are presented in Appendix D. Figure 7.1 presents a combined view of rainfall and the resulting water levels in all production bores. During the review period, water levels rose in the 2019/20 water year due to significant rainfall in February 2020 and again in the 2020/21 water year due to significant rainfall/riverflow in February 2021.

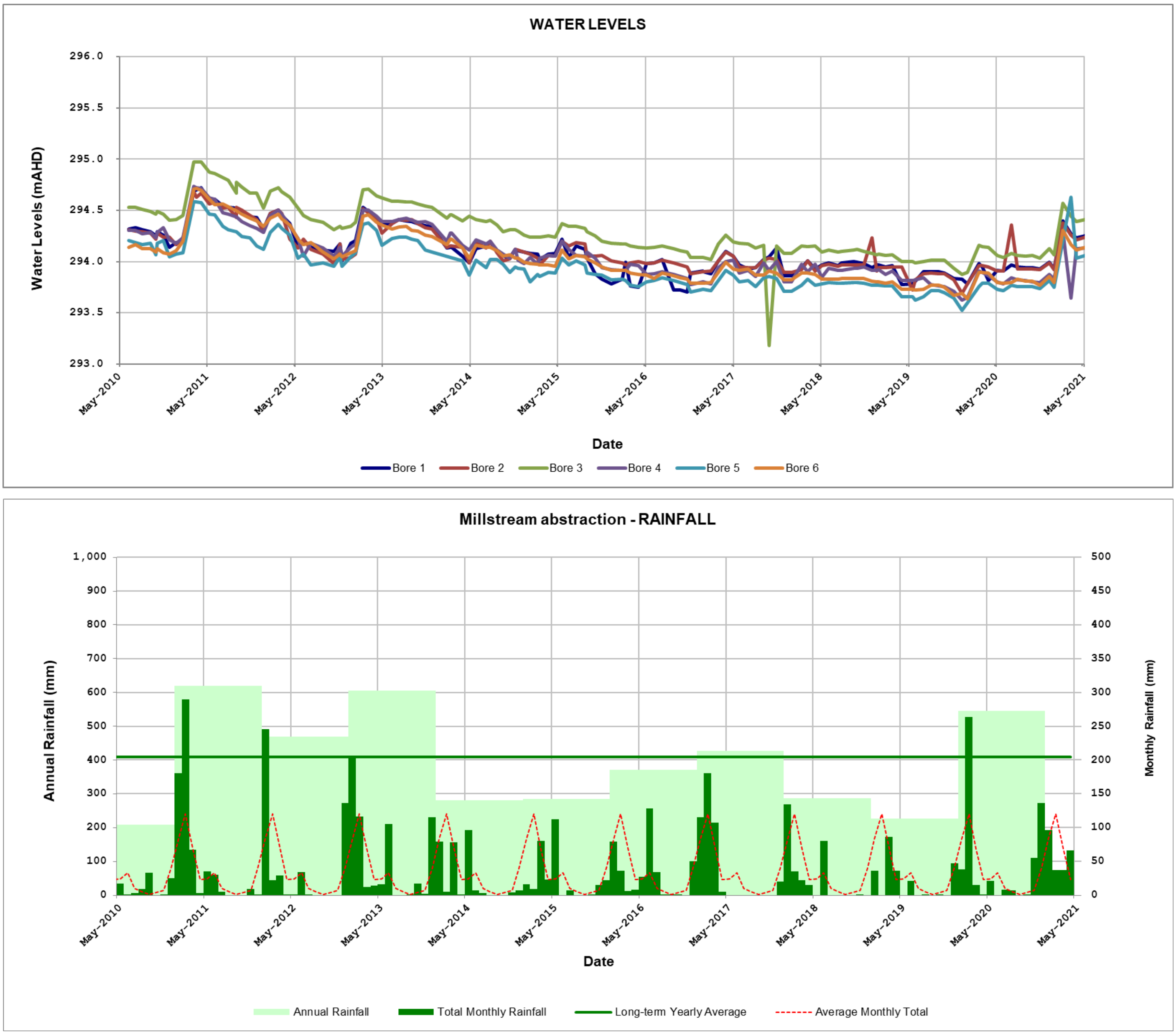


Figure 7.1 Millstream Production Bore Water Levels

7.1.3 Millstream Supplementation Bore Levels

The Deep Reach and Chinderwarriner supplementation bores were not required to be operated during the review period. Monthly water levels were not taken in the 2020/21 due to an administration error as it was thought no monitoring was required when the bores are not in use. Historical water levels for these bores are presented in Figures 7.2 and 7.3.

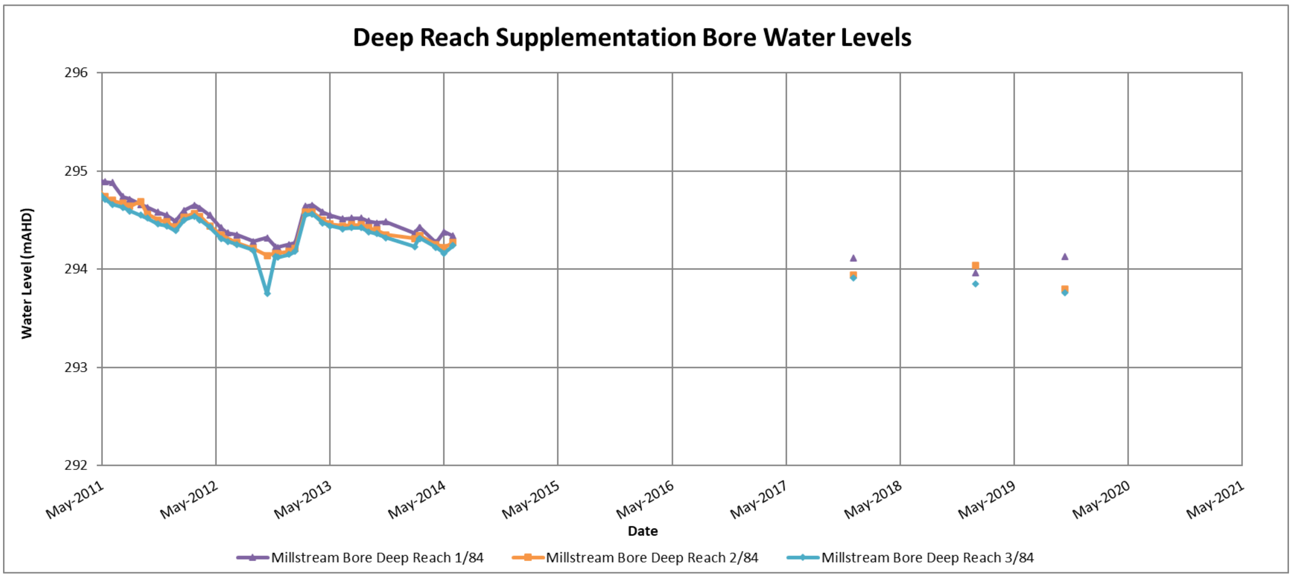


Figure 7.2 Deep Reach Supplementation Bore Water Levels

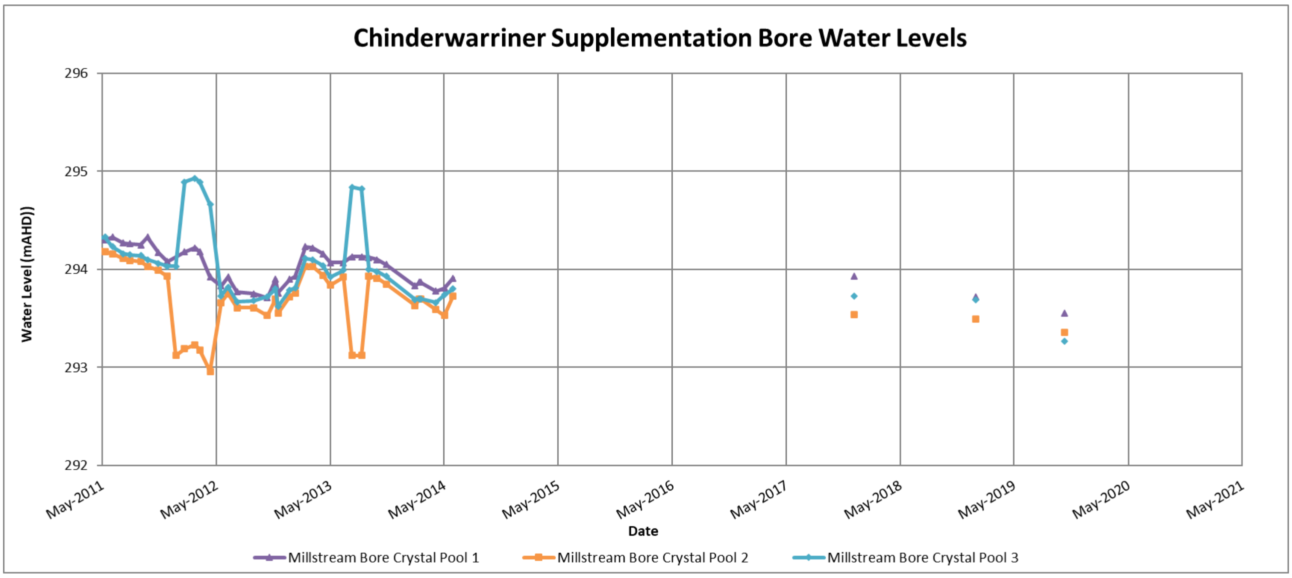


Figure 7.3 Chinderwarriner Supplementation Bore Water Levels

7.1.4 MAL8 and 7A Monitoring Bore Levels

Monitoring results for the MAL8 bores and bore 7A are presented in hydrographs in Appendix E. Figure 7.4 presents the bi-monthly mean aquifer level (MAL) and the long term average mean aquifer level (MAL) against annual rainfall.

During the review period the MAL reached a low of 293.794 mAHD in January 2020 and high of 294.138 mAHD in March 2021. Similarly, levels in Bore 7A reached a low of 293.66 mAHD in January 2020 and a high of 294.05 mAHD in March 2021. The MAL remained above the environmental criteria level for the review period of 293.6 mAHD, based on the recharge class of 2.

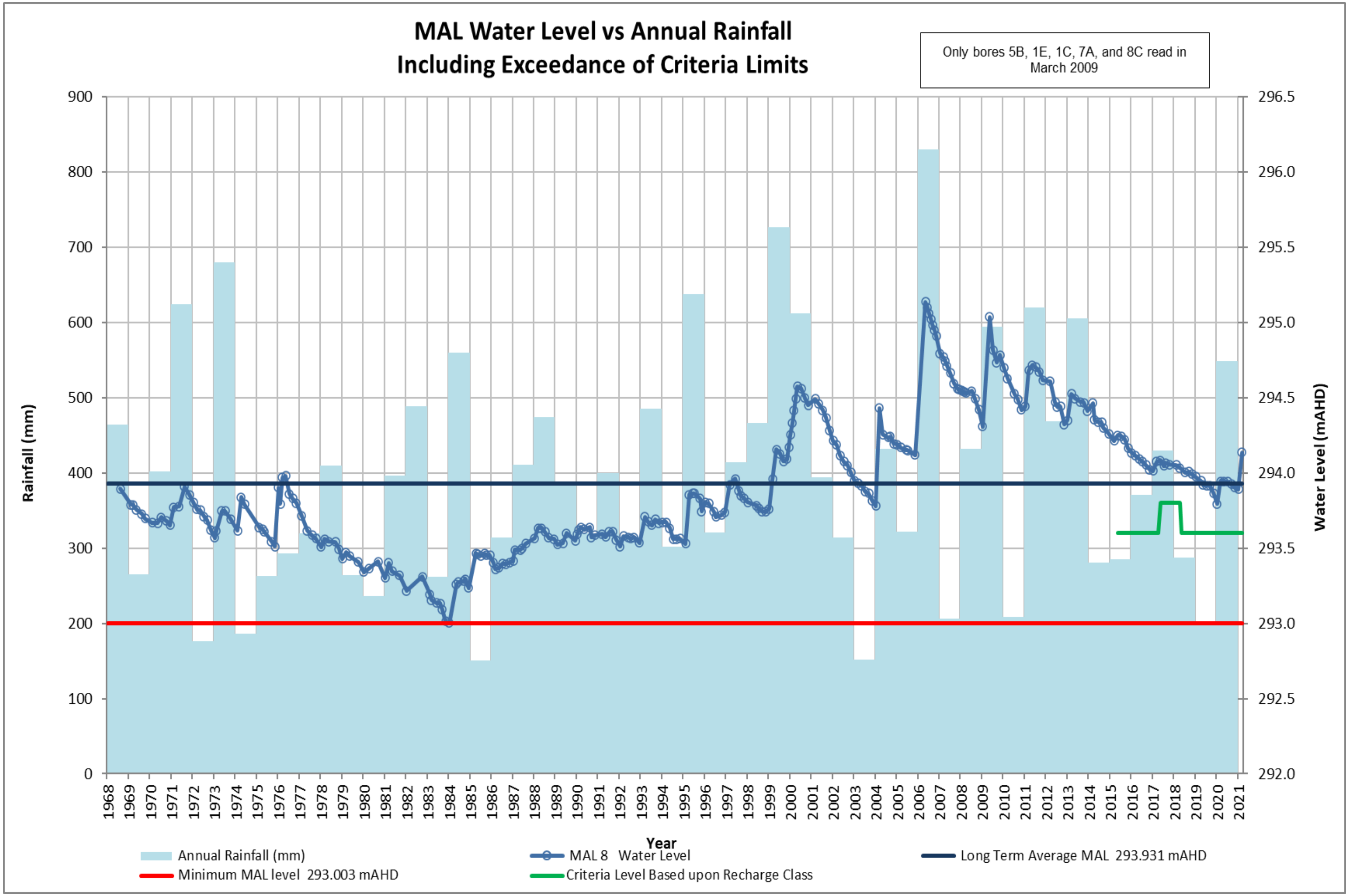


Figure 7.4 MAL Water Levels

7.1.5 Millstream Environ Monitoring Bore Water levels

Hydrographs for the Millstream Environ monitoring bores are presented in Appendix E. Data was obtained from ODSS database and water levels are presented as metres AHD.

Water levels in most bores within the Millstream Delta dropped below the 5%ile criteria every year of the review period except for Riverine bores P10 and P7/77 as shown in Table 7.2. Water levels in all the bores have recovered slightly, due to significant riverflow in February and December 2020 and January 2021, but minimum water levels still dropped below the criteria level.

Table 7.2 Minimum Millstream Environ monitoring bore water levels

Applicable Criteria	5th%ile Criteria	20th%ile Trigger	50th%ile Trigger	Minimum measured Water Level (mAHD)	Comparison to 5%ile criteria (m)	Minimum measured Water Level (mAHD)	Comparison to 5%ile criteria (m)	Minimum measured Water Level (mAHD)	Comparison to 5%ile criteria (m)
				WY 2018/19 (mAHD)		WY 2019/20 (mAHD)		WY 2020/21 (mAHD)	
Riverine and delta vegetation									
P10 (Riverine)	≥270.07mAHD	≥270.28mAHD	≥270.70mAHD	270.34	0.27	271.45	1.38	271.18	1.11
P7/77(Riverine)	≥290.46mAHD	≥290.70mAHD	≥291.02mAHD	290.09	-0.37	290.48	0.02	290.60	0.14
P8/77 (Riverine)	N/A	N/A	N/A	293.80	N/A	293.68	N/A	293.78	N/A
P7/78 (Riverine)	N/A	N/A	N/A	293.87	N/A	293.66	N/A	293.87	N/A
P9A/78 (Riverine)	N/A	N/A	N/A	294.43	N/A	294.37	N/A	294.47	N/A
P8/04 (Riverine)	N/A	N/A	N/A	293.93	N/A	293.81	N/A	-	N/A
03/04 (Delta)	≥285.76mAHD	≥285.81mAHD	≥285.86mAHD	285.39	-0.37	285.19	-0.57	-	N/A
12/04 (Delta)	≥283.96mAHD	≥284.14mAHD	≥284.27mAHD	283.93	-0.03	283.57	-0.39	283.91	-0.05
04/04 (Delta)	≥287.32mAHD	≥287.43mAHD	≥287.65mAHD	287.28	-0.07	287.25	-0.07	287.32	0.00
P2/77 (Delta)	≥278.70mAHD	≥279.28mAHD	≥279.73mAHD	277.80	-0.90	278.08	-0.62	278.35	-0.35
P3/77 (Delta)	≥278.01mAHD	≥278.20mAHD	≥278.35mAHD	276.97	-1.04	277.65	-0.36	277.82	-0.19
P4/78 (Delta)	≥283.22mAHD	≥283.51mAHD	≥283.79mAHD	282.46	-0.76	282.63	-0.59	282.80	-0.42
Palm Springs P2	≥278.74mAHD	≥278.80mAHD	≥278.93mAHD	278.46	-0.28	278.40	-0.34	278.56	-0.18
P8	N/A	N/A	N/A	292.33	N/A	292.13	N/A	292.35	N/A

7.1.6 Pool, Creek and Gregory Gorge Flows

Chinderwarriner Pool outflow data and target flow for the past 10 years is shown in Figure 7.5. The target outflow for the review period up to June 2020, based on a recharge of 2, was ≥0.16 kL/s. Outflow was at its lowest at 0.222 kL/s in May 2019 which was well above the target. In June 2020, new criteria were introduced which also included water level criteria for nearby bore 1E. For the 2020/21 water year based on a recharge class of 2, the trigger flow rate and water level are 0.23 kL/s and 293.58 mAHD respectively, and the criteria flow rate and water level are 0.20 kL/s and 293.49 mAHD. These criteria for 2020/21 were fully met as shown in Figure 7.5.

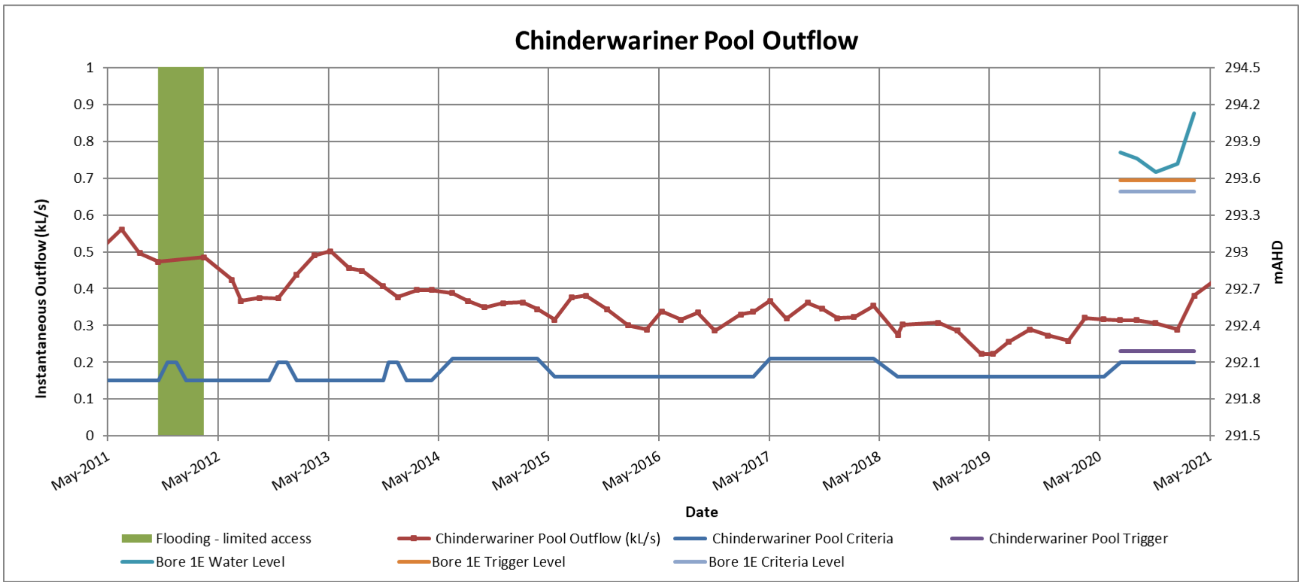


Figure 7.5 Flow rate for Chinderwarriner Pool Outflow

Outflows from Peters, Woodley and Palm Creeks are shown in Figure 7.6 at both full and reduced flow range scales. During the review period, the rates at Woodley and Peters Creeks have been zero or close to zero at the time of each measurement during each water year. Palm Creek instantaneous flow rate has ranged between 1.50 and 8.94 L/s during the review period. In June 2020 new flow requirements for the creeks were introduced in which for a recharge class of 2, flow was required in Palm and Peters Creeks and no flow was required for Woodley Creek during the water year. These new requirements were met.

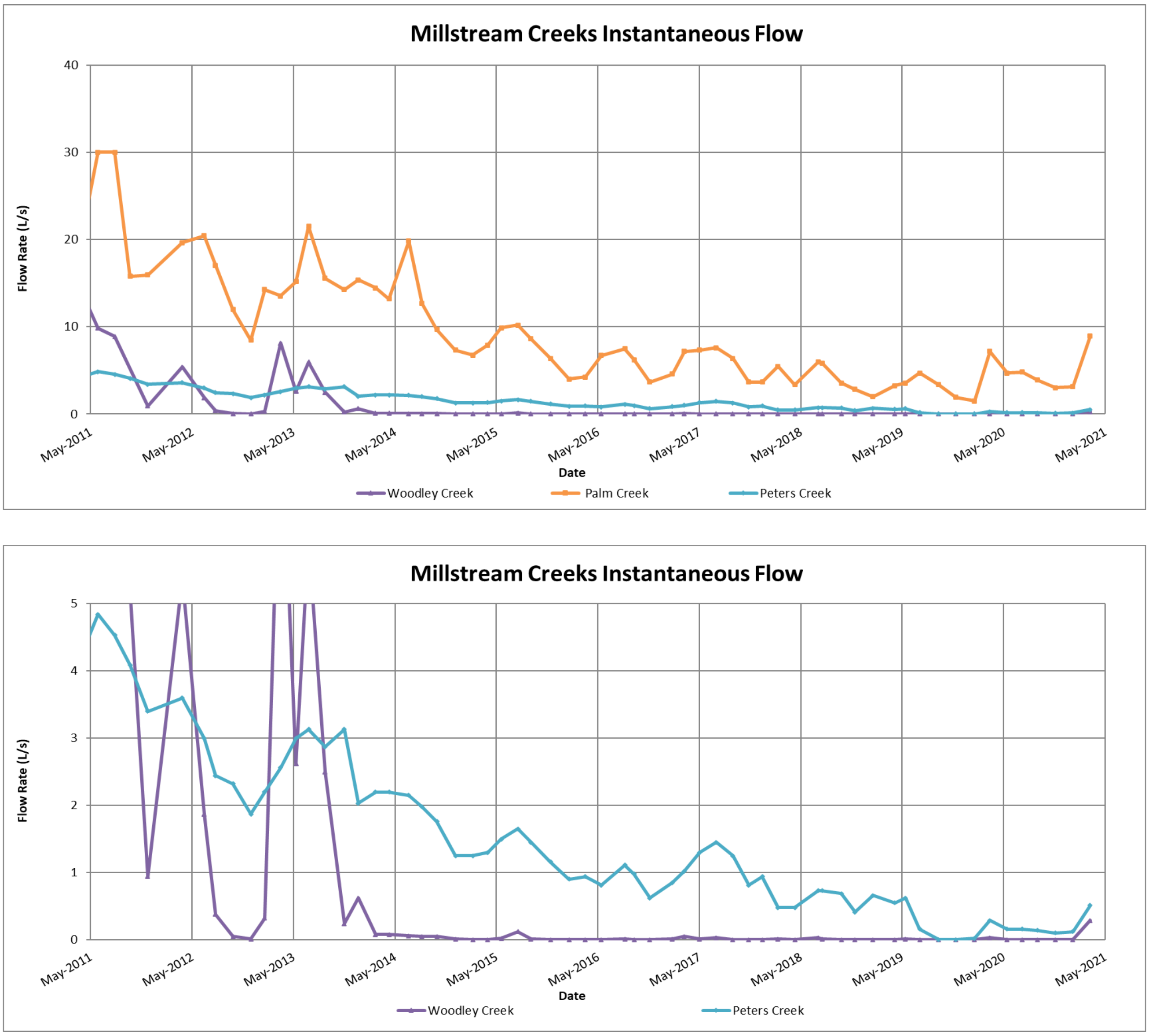


Figure 7.6 Flow rates for Peters, Woodley and Palm Creeks

Crossing Pool outflow data and target flow for the past 10 years is shown in Figure 7.7. The target outflow for the review period up to June 2020, based on a recharge of 2, was ≥0.14 kL/s. Outflow was at its lowest at 0.166 kL/s in November 2019 which was above the target. In June 2020, new criteria was introduced which also included water level criteria for nearby bore 5B. For the 2020/21 water year based on a recharge class of 2, the trigger flow rate and water level is 0.23 kL/s and 293.98 mAHD respectively, and the criteria flow rate and water level is 0.21 kL/s and 293.78 mAHD. The flow rate trigger was breached in November 2020 and January 2021, while the flow rate criteria was breached in November 2020. However, the level in bore 5B was always above its criteria level but did go below its trigger level in November 2020. Compliance against these new criteria for 2020/21 are shown in Figure 7.7.

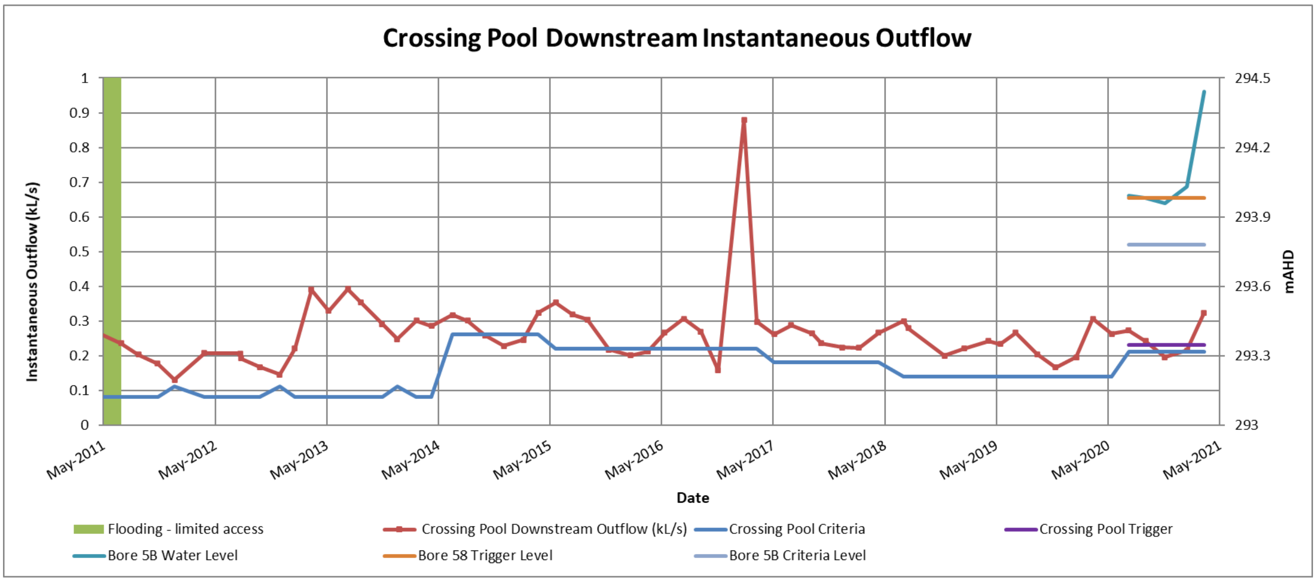


Figure 7.7 Crossing Pool Downstream Instantaneous Outflow

The Gregory Gorge flow has criteria which specifies the allowable period of no flow depending on the recharge class. The recharge class for the whole of the review period was 2 which corresponds to a period of no flow not greater than three months. As shown in Figure 7.8 (where the full flow range is not shown) the maximum no flow period monitored was two months, October and November 2019.

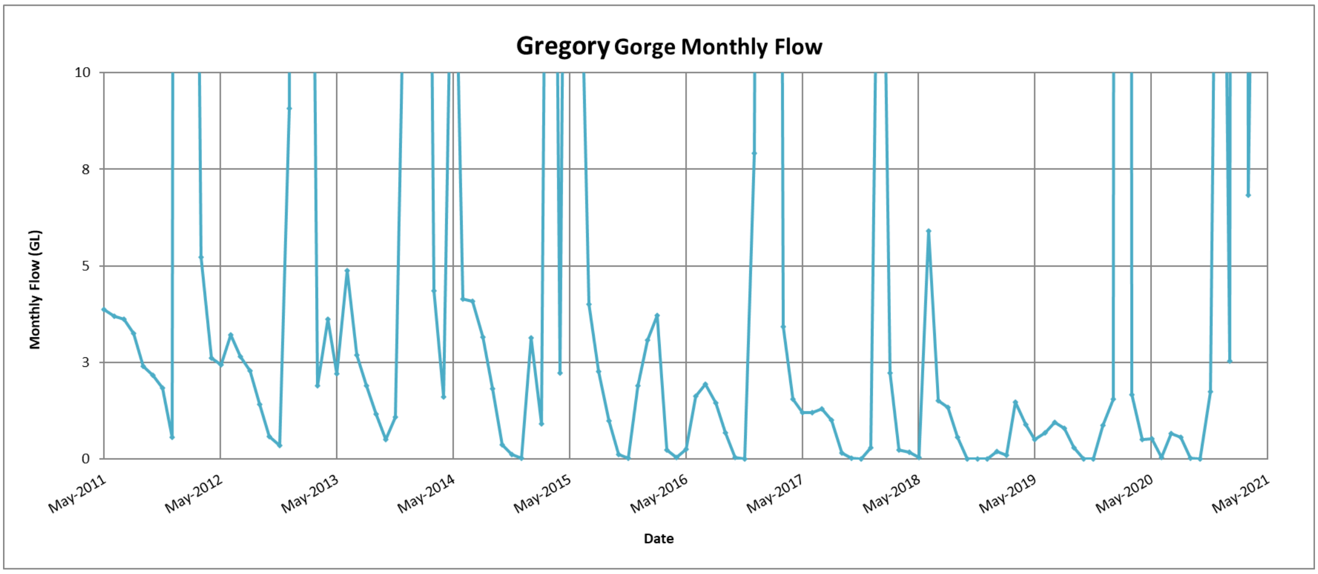


Figure 7.8 Gregory Gorge Monthly Flow

7.2 Water Quality

The water quality criteria for Water Corporation potable water supply schemes are based on the Australian Drinking Water Guidelines authored by the National Health and Medical Research Council (NHMRC) and specified in the corporate standard S010 Drinking Water Quality Performance. Water quality monitoring required to be undertaken by the Water Corporation is detailed in the West Pilbara Water Supply Scheme WRMOS 2014.

7.2.1 Salinity

Salinity, recorded as Total Dissolved Solids (TDS) derived from electrical conductivity, for each production bore is shown in a time series plot in Appendix D. The relationship used to determine TDS (mg/L) by conductivity (mS/m) for the Millstream groundwater source is:

$$\text{TDS (mg/L)} = \text{EC (mS/m)} \times 5.2 + 104.8$$

Salinity at the Millstream Borefield ranged from 579 to 907 mg/L TDS over the review period and, even though it slightly decreased in comparison to the previous review period, levels are within their historical range.

Salinity in Chinderwarriner Pool is shown in Figure 7.8. Salinity levels were more variable and slightly lower than the previous review period, with Total Dissolved Solids (TDS) remaining under the target level of 1,086 mg/L. Salinity in Deep Reach Pool is shown in Figure 7.9 with TDS remaining under the target level of 1,400 mg/L during the review period. The low salinity spikes appear to correspond to riverflow events. The Deep Reach and Chinderwarriner supplementation bores were not required to be operated during the review period. Consequently, there was no water quality sampling undertaken as this is only required when the bores are in operation.

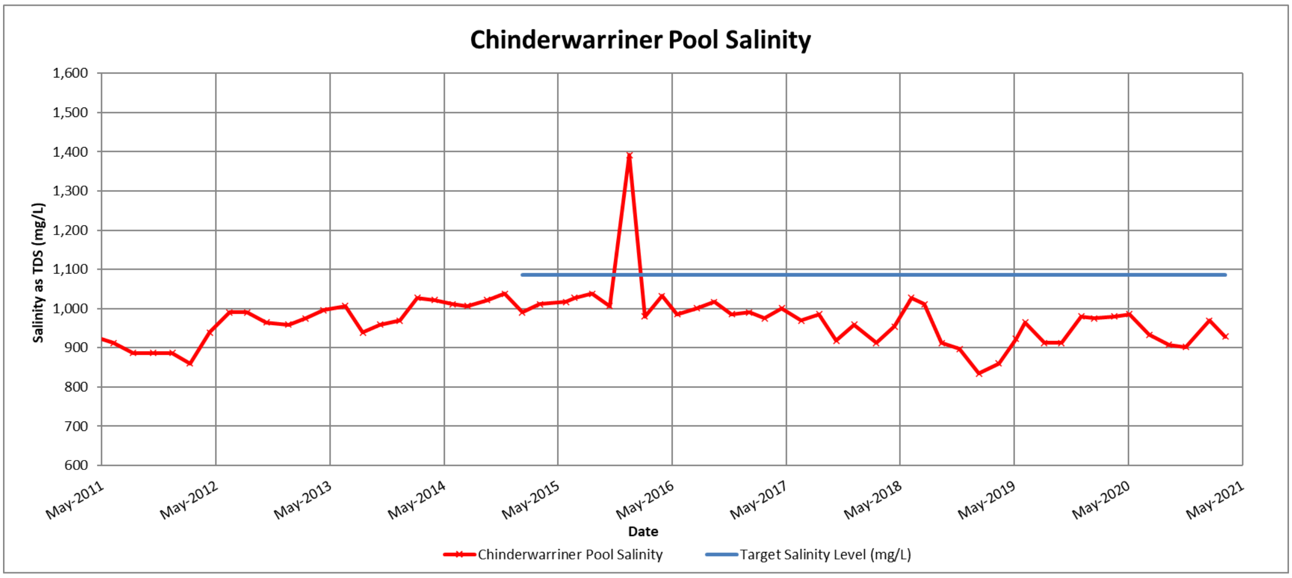


Figure 7.8 Chinderwarriner Pool Salinity

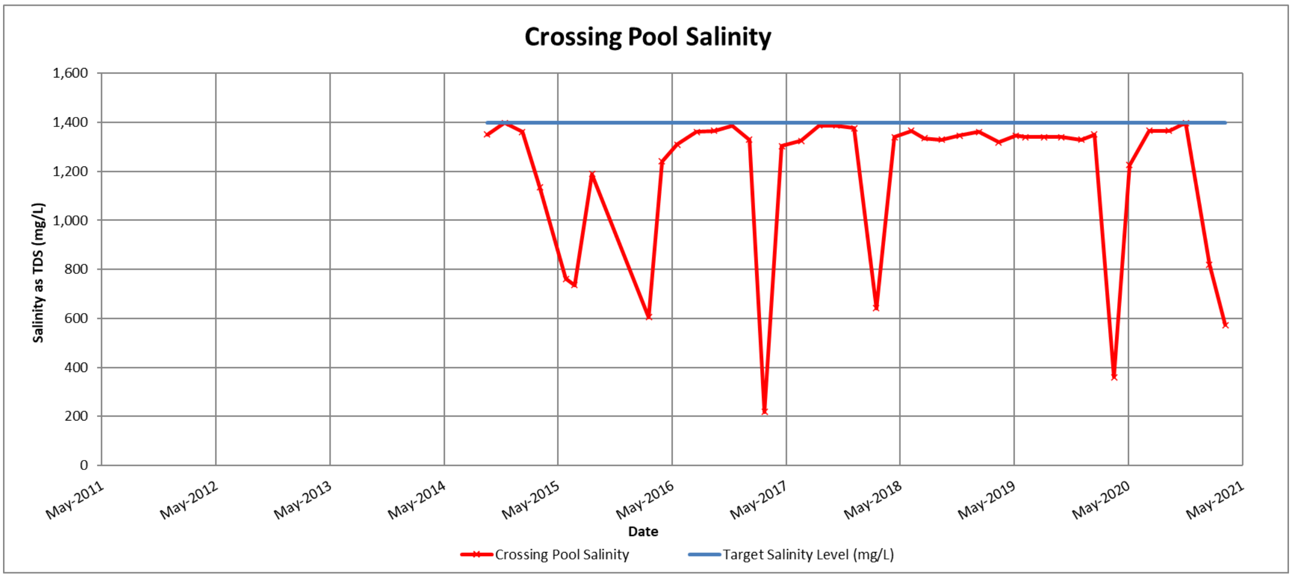


Figure 7.9 Deep Reach Pool Salinity

7.2.2 Chemical Parameters

A summary of the water quality results obtained during the water year are shown in Appendix F. All health-related chemical parameters were found to be within 2011 NHMRC guideline levels. The groundwater at Millstream is naturally hard and aesthetic guideline levels for hardness were consistently exceeded in all production bores, with values up to 460 mg/L in Bore 5. Water quality levels were not significantly different to prior years.

7.2.3 Climate

Climate Monitoring to be undertaken by the Water Corporation is detailed in the West Pilbara Water Supply Scheme WRMOS 2014. Rainfall and pan evaporation data at Bureau of Meterology (BoM) station 5012 was obtained from the SILO database (Government of Queensland, 2021) and rainfall data is presented in Section 2.

7.3 Harding Dam

7.3.1 Dam Storage Levels

Water level at Harding Dam during the review period initially continued to decrease to low levels due to the lack of significant rainfall events, but then rose in February 2020 when significant rainfall occurred as a result of tropical cyclone Damien. Levels once again rose in February 2021 due to further significant rainfall. The resultant inflow into the dam was not sufficient to cause the dam to overflow with the maximum storage reaching 79% of capacity. The lowest storage level reached for the review period was 52.28 m and volume was about 12.05 GL, which was above the minimum operating level but below the Corporation's minimum operation level for water quality of approximately 53 mAHD. Water levels and storage volumes are presented graphically in Figures 7.10 and 7.11 respectively.

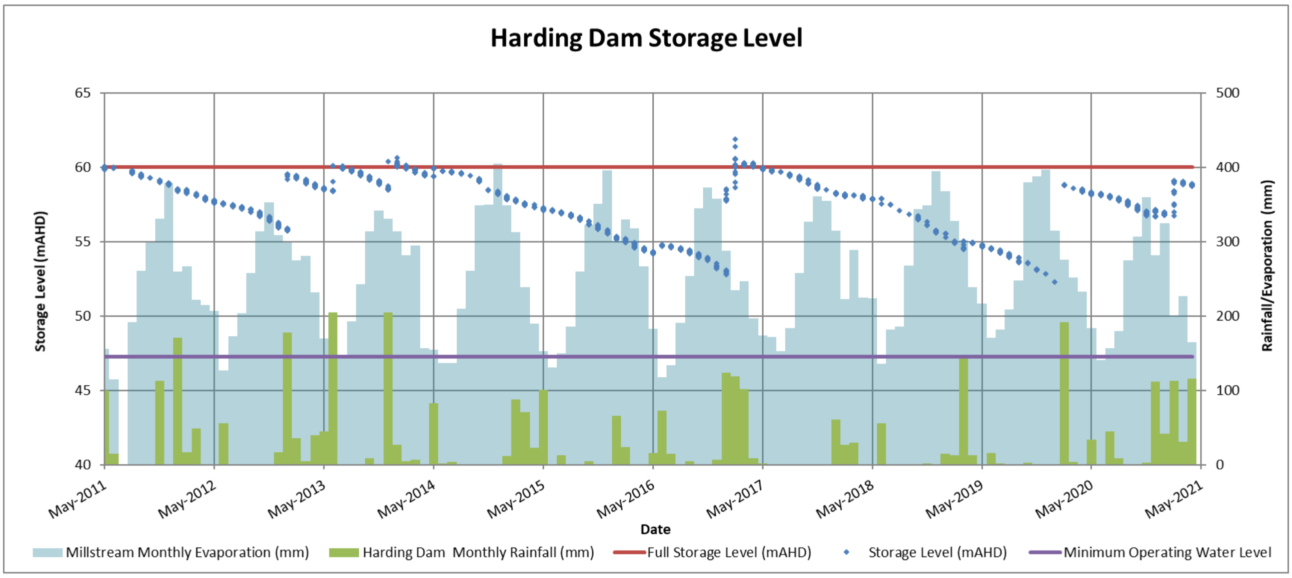


Figure 7.10 Harding Dam Storage Level

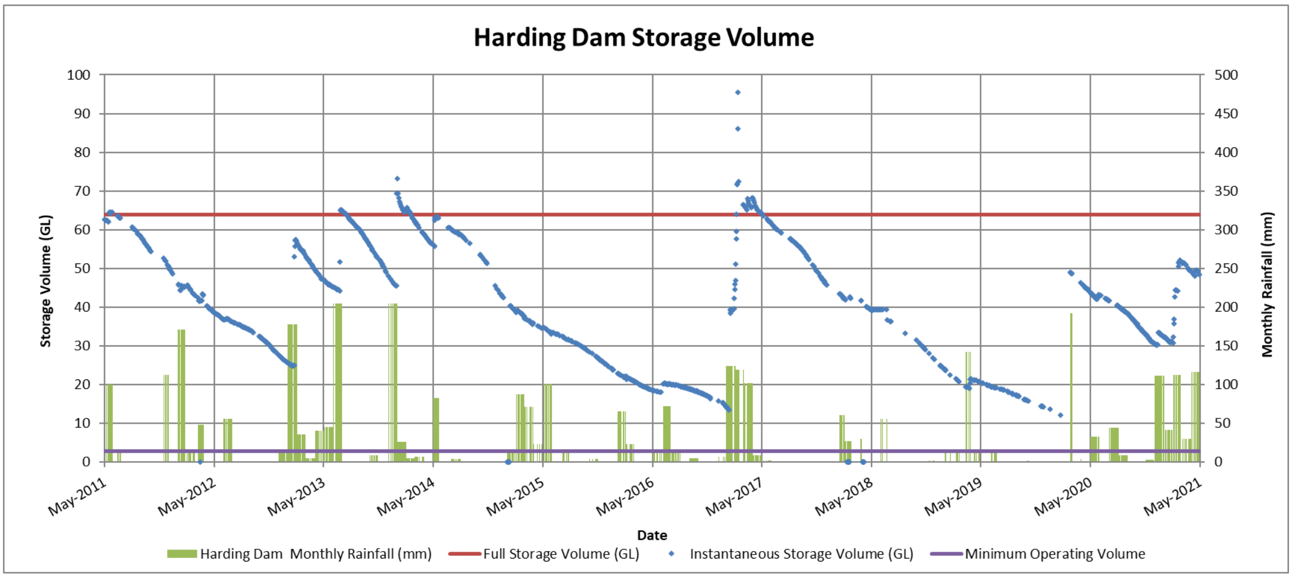


Figure 7.11 Harding Dam Storage Volume

7.3.2 Pool and Monitoring Bore Levels

Downstream pool and groundwater levels are shown in Figures 7.12, 7.13 and 7.14. Water levels in all bores and pools (except for Recreational Pool, Warranoolar Pool and Bores 1/81 and 2/00 adjacent to Warranoolar Pool), declined during the initial part of the review period to their lowest level since 2011 until there was significant rainfall in February 2020. Water levels at the end of the water year were at or near to their highest levels since 2017.

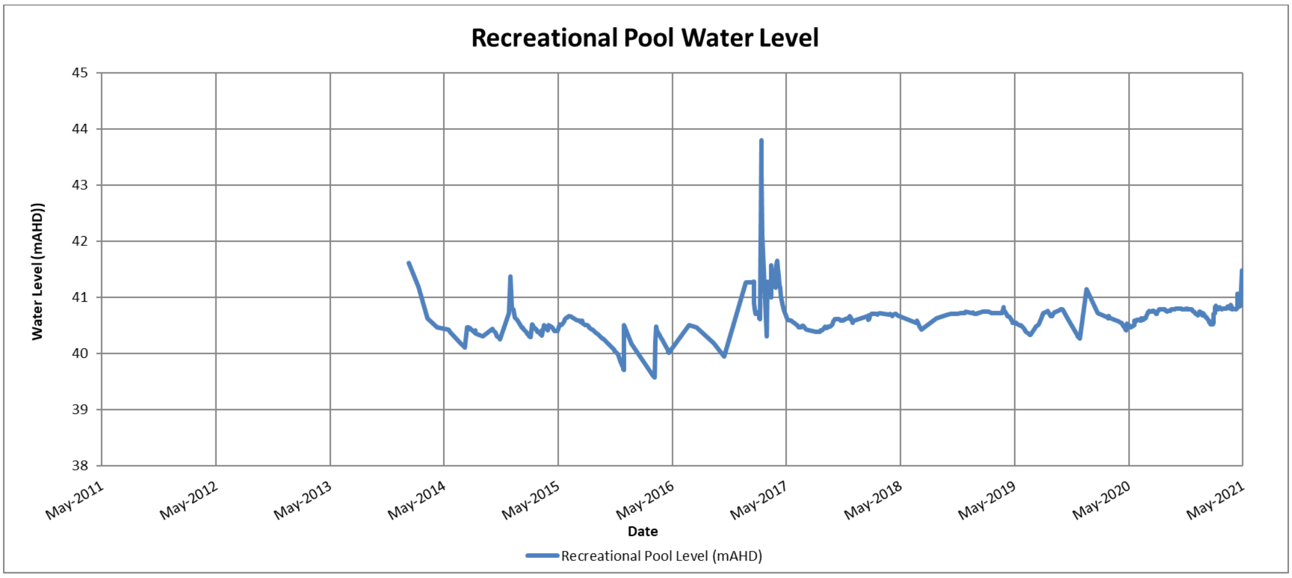


Figure 7.12 Recreational Pool Level

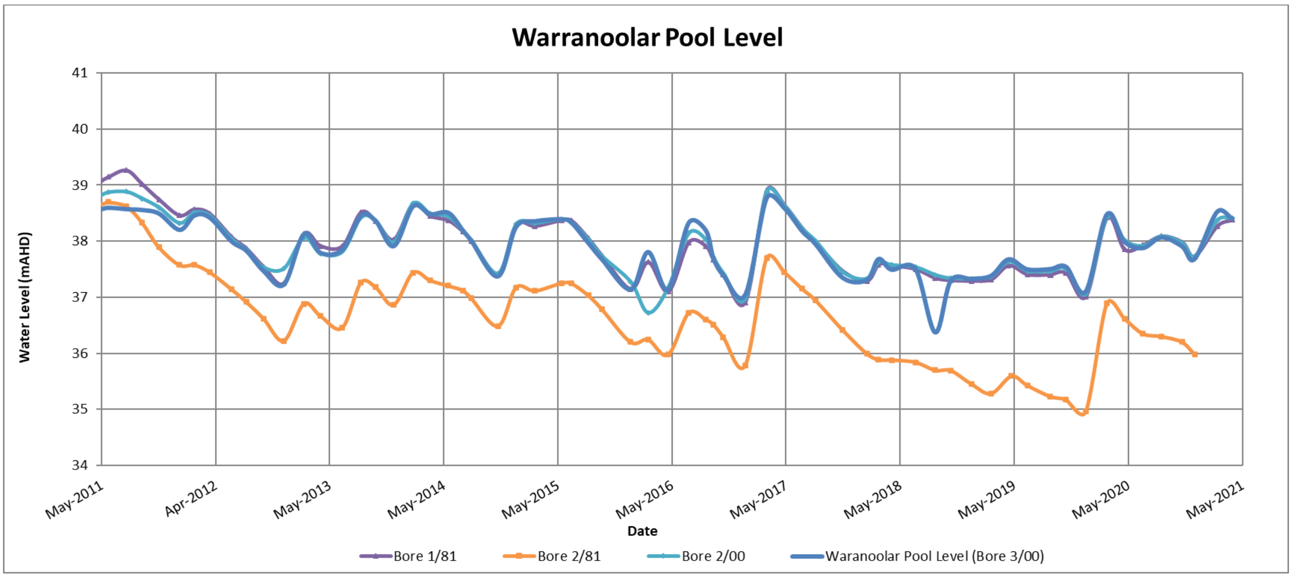


Figure 7.13 Warranoolar Pool Level

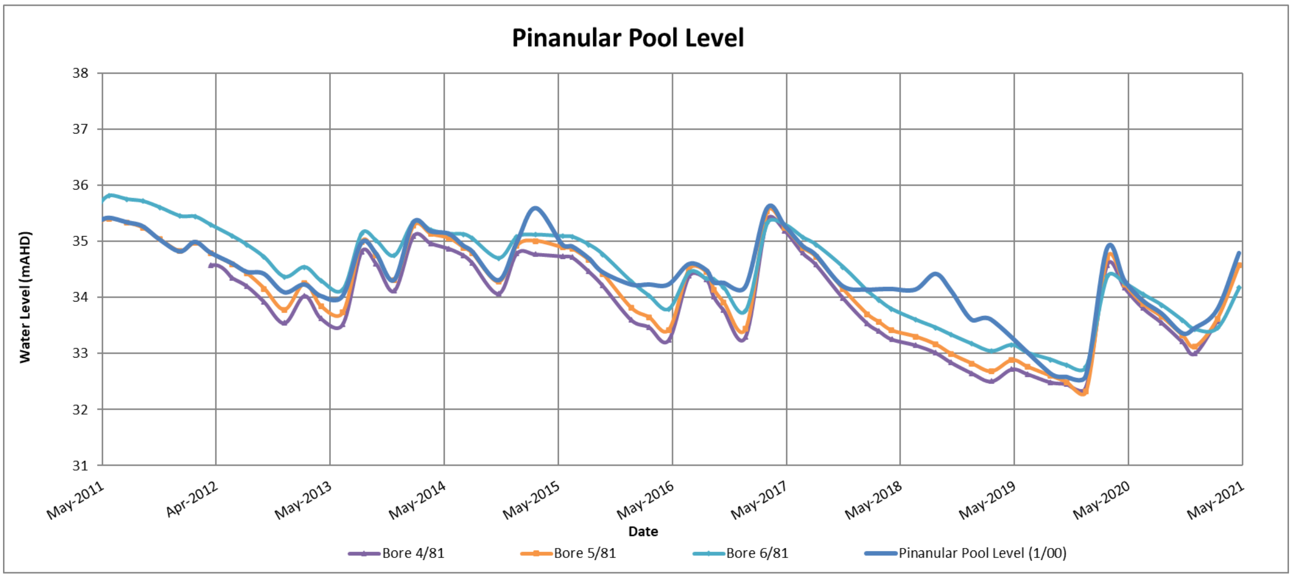


Figure 7.14 Pinannular Pool Level

For monitoring Bore 5/81, located close to Pinannular Pool, a trigger level of 32.5m AHD was set in the 2014 WRMOS. In October 2019 the level in this bore fell below the trigger level. As a consequence, and as the water level in Harding Dam was below the Corporation's minimum operation level for water quality, it was agreed with DWER to release water from Harding Dam. The release of water commenced January 3 and ceased on January 16. An estimated 1.4 GL was released during this period and water levels in Bore 5/81 rose by approximately 2 m. This release also resulted in the increase in water levels at Warranoolar Pool. Water levels for Bore 5/81 are shown in Figure 7.15.

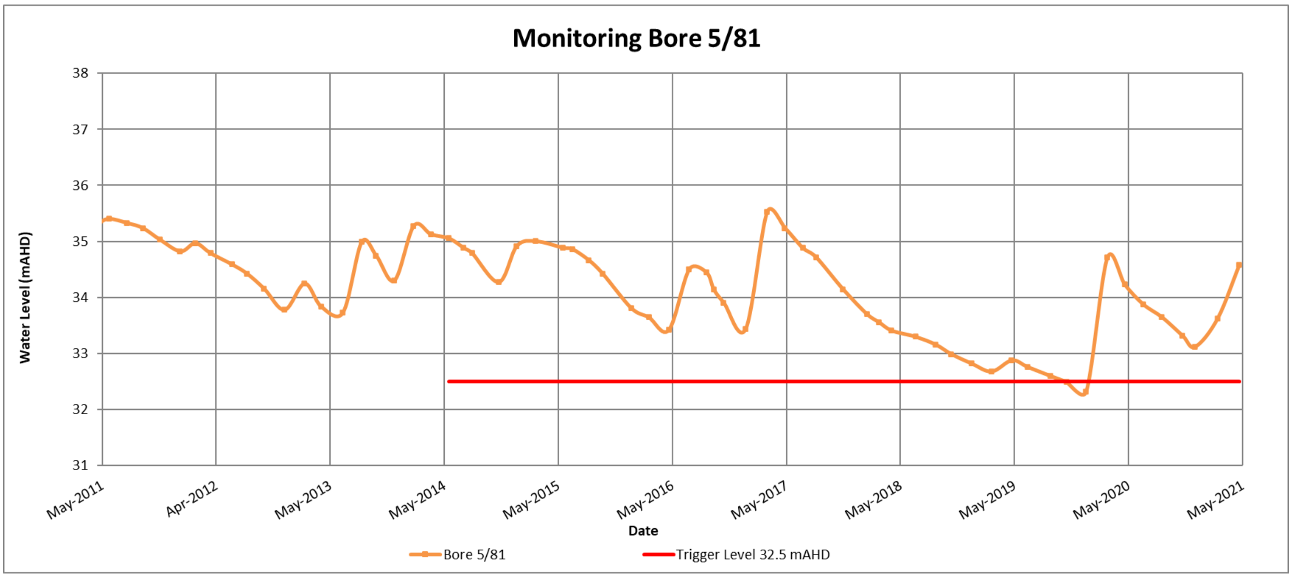


Figure 7.15 Bore 5/81 Water Levels

7.3.3 Water Quality

Water quality monitoring required to be undertaken by the Water Corporation is detailed in the West Pilbara Water Supply Scheme WRMOS 2014. A summary of the water quality results obtained during the water year are shown in Appendix F. The Dam water was generally of good quality and generally met the 2011 NHMRC guidelines for drinking water in Australia. Colour, manganese and pH exceeded the aesthetic guidelines on occasions.

All health-related chemical parameters remained within NHMRC guideline values. The raw dam water undergoes microfiltration and is disinfected with chlorine to ensure microbiological quality of the drinking water supplied to consumers.

7.3.4 Supernatant Discharge

Limited scour valve discharge to Recreational Pool occurred during the review period. The times when the scour valve was opened are shown in Table 7.5.

Table 7.5 Scour valve opening times

Reading Date	Scour Valve Position	Valve Open Time	Valve Shut Time
	(% open)	(Time)	(Time)
25/02/2020	20	1000	1030
3/03/2020	20	0957	1027
14/04/2020	20	0848	0924
21/04/2020	20	0840	0911
28/04/2020	20	0848	0929
26/05/2020	20	0850	0923
22/07/2020	20	1030	1113
5/10/2020	20	0044	0045
1/12/2020	20	0909	0941
22/12/2020	20	0757	0834
19/01/2021	20	0853	0929
23/03/2021	10	0905	0935
30/03/2021	10	0758	0852
24/04/2021	20	0700	
06/05/2021	20		0820

The supernatant discharge to Recreational Pool is detailed in Table 7.6. These values have been estimated based on 5% of the outflow from the Dam as stipulated in the WRMOS.

Table 7.6 Supernatant Discharge during the Water Year

Water Year		Harding Dam (ML)	Supernatant discharge (ML)
2018/19	May	195.60	9.78
	Jun	0.00	0.00
	Jul	32.23	1.61
	Aug	450.92	22.55
	Sep	508.62	25.43
	Oct	736.64	36.83
	Nov	684.95	34.25
	Dec	621.74	31.09
	Jan	727.72	36.39
	Feb	478.87	23.94
	Mar	373.37	18.67
	Apr	22.23	1.11
	Total	4,832.88	241.64
2019/20	May	10.57	0.53
	Jun	18.66	0.93
	Jul	429.58	21.48
	Aug	336.42	16.82
	Sep	492.50	24.63
	Oct	216.27	10.81
	Nov	7.22	0.36
	Dec	10.09	0.50
	Jan	0.14	0.01
	Feb	0.02	0.00
	Mar	4.91	0.25
	Apr	14.89	0.74
	Total	1,541.27	77.06
2020/21	May	29.23	1.46
	Jun	117.35	5.87
	Jul	381.02	19.05
	Aug	471.02	23.55
	Sep	628.45	31.42
	Oct	622.46	31.12
	Nov	436.15	21.81
	Dec	8.62	0.43
	Jan	24.67	1.23
	Feb	513.19	25.66
	Mar	774.01	38.70
	Apr	315.00	15.75
	Total	4,321.17	216.06

8. Impact of Borefield Operations

Rainfall events that occurred in February 2020 and 2021 resulted in Harding Dam filling to 79%. Limited use of the dam occurred during the 2019/20 water year due to low water level in the dam and water quality issues.

The variation in groundwater levels within the Millstream aquifer during the water year exhibited a typical historical sequence of natural depletion and recharge within the historical range. Water levels gradually declined until early 2020 but rose in early 2020 and again in early 2021 due to rainfall events.

During the review period, the MAL level for the Millstream aquifer has remained above environmental criteria. Based upon the past two year's performance of the MAL and assuming minimal rainfall events, the criteria level is not expected to be breached for at least two years.

Water levels within the Millstream environmental monitoring bores have generally remained within historical ranges. However, levels in most of these bores were generally below the 5%ile and 20%ile criteria with 2020/21 levels much higher. Flows in creeks and from pools were also generally above criteria levels.

Pools downstream of Harding Dam have also continued to exhibit a typical historical sequence of natural depletion and recharge within the historical range. Levels continued to decline up to early 2020 but then rose due to significant rainfall events.

The above observations indicate that during the review period there have been no adverse impacts as a result of the operation of the Millstream borefield and the Harding Dam.

8.1 Adequacy of Current Monitoring Program

The current monitoring program for the West Pilbara scheme was reviewed and approved in September 2016. The Millstream monitoring program was subsequently reviewed in 2019 resulting in a WRMOS Addendum approved in June 2020. This program is considered adequate to manage the risks associated with the operation of this scheme and no changes are proposed as a consequence of this review.

9. Agreed Actions

The following table lists the actions and the status from the last Water Monitoring Summary.

Table 9.1 Actions resulting from previous Water Monitoring Summary

Item	Actions from Previous Water Monitoring Review	Status
1	Assess requirement for conductivity sampling of Bores PB7 and PB8 and, if required, develop a method for their monitoring - ADR14438	Ongoing

The following table lists the actions from this Water Monitoring Review.

Table 9.2 Actions resulting from this Water Monitoring Review

Item	Action	Timing	Responsibility
1	Revise WRMOS monitoring program once the redrilled MAL Bores and Bore 7A are surveyed and remote monitoring of these bores are commissioned.	December 2022	OAM

10. References

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11. Appendices

APPENDIX A
Groundwater Licences

File No: RF9621

Government of **Western Australia**
Department of **Water and Environmental Regulation**

Instrument No. GWL105696(7)

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	Water Corporation		
Description of Water Resource	Pilbara Hamersley - Millstream	**Annual Water Entitlement**	15,000,000kL
Location of Water Source	Crown Reserve 36991, Lot 55 Millstream (Bores PB1, PB2, PB3, PB4, PB5, PB6 Millstream Borefield) Crown Reserve 36991, Lot 58 Millstream (Bores PB7, PB8, PB9, PB10, Millstream Borefield) Lot 128 Fortescue Millstream Wellfield		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Water Supply for Public Scheme	Crown Reserve 36991, Lot 55 Millstream (Bores PB1, PB2, PB3, PB4, PB5, PB6 Millstream Borefield)
	Water Supply for Public Scheme	Crown Reserve 36991, Lot 58 Millstream (Bores PB7, PB8, PB9, PB10, Millstream Borefield)
Duration of Licence	From 22 October 2018 to 11 May 2024	

This Licence is subject to the following terms, conditions and restrictions:

1. The annual water year for water taken under this licence is defined as 1 May to 30 April.

2. The licensee shall comply with the commitments of the operating strategy "West Pilbara Water Resource Management Operation Strategy, February 2014", as prepared by Water Corporation and approved by the Department of Water and Environmental Regulation on 6/5/2014 including any modifications to the commitments as approved during the term of the licence.

3. Every 12 Months the licensee shall provide to the Department of Water and Environmental Regulation a Groundwater Monitoring Summary for the preceding water year. The first report is due 31/07/2019.

4. Every 5 Years the licensee shall provide to the Department of Water and Environmental Regulation a Groundwater Monitoring Review. The first report is due 31/10/2021. A Groundwater Monitoring Summary need not be submitted in a year in which a Groundwater Monitoring Review is due.

End of terms, conditions and restrictions

This Licence is granted subject to the Rights in Water and Irrigation Regulations 2000.

LICENCE TO TAKE WATER

Granted by the Minister under section 5C of the Rights in Water and Irrigation Act 1914

Licensee(s)	Water Corporation		
Description of Water Resource	Harding Upper Harding	**Annual Water Entitlement**	15,000,000kL
Location of Water Source	210, , COOYA POOYA		

Authorised Activities	**Taking of water for**	**Location of Activity**
	Water Supply for Public Scheme	210, , COOYA POOYA
Duration of Licence	From 22 October 2018 to 11 May 2024	

This Licence is subject to the following terms, conditions and restrictions:

1. The annual water year for water taken under this licence is defined as 1 May to 30 April.
2. The licensee shall comply with the commitments of the operating strategy "West Pilbara Water Resource Management Operation Strategy, February 2014", as prepared by Water Corporation and approved by the Department of Water and Environmental Regulation on 6/5/2014 including any modifications to the commitments as approved during the term of the licence.
3. Every 12 Months the licensee shall provide for the preceding water year a surface water monitoring summary. The first report is due 31/07/2019. The report is to contain a summary of all monthly data and analysis of impacts from extraction.
4. Every 5 Years the licensee shall provide a surface water monitoring review. The first report is due 31/10/2021. The review is to contain a complete history of monitoring data and detailed analysis of impacts from extraction. A surface water monitoring summary need not be submitted in a year that a review is due.
5. That the combined total draw under this licence and groundwater licence number 105696 shall not exceed 15,000,000 kilolitres per annum.

End of terms, conditions and restrictions

This Licence is granted subject to the Rights in Water and Irrigation Regulations 2000.

APPENDIX B
Bore Information Sheets

BORE DETAILS					
Bore Number	PB1	PB2	PB3	PB4	PB5
Functional Location Number	W0026735	W0026740	W0026741	W0026742	W0026743
Date Drilled	26/06/1969	Relined 2011	12/06/1971	Relined 2013	Relined 2013
Bore Type	Production	Production	Production	Production	Production
Zone	50	50	50	50	50
MGA Easting	506880.5	506864.3	506831.5	507079	507051.5
MGA Northing	7612178.7	7611970.5	7611524.6	7611723.1	7611934.3
BORE CONSTRUCTION					
Casing Diameter (mm)	381	365	394	370	370
Casing Type	Mild Steel	Stainless	Mild Steel	Stainless	Stainless
Screen/Slot Interval (m BTOC)	7.01-17.07	2.3 - 14.3	12.8-19.21	6.75-15.75	7.7-16.7
Screen/Slots	Slots	Screen	Slots	Screen	Screen
Bore Depth (m BTOC)	19.2	14.3	21.64	16.75	17.5
SWL when drilled (m BTOC)	5.16	2.05	11.98	4.22	4.86
REDUCED LEVELS					
Height Datum	AHD	AHD	AHD	AHD	AHD
Top of Casing (m)	299.03	296.57	301.0714	298.662	299.106
Bottom of Bore (m)	279.83	282.27	279.4314	281.912	281.606
Top of Screens (m)	292.02	294.27	288.2714	291.912	291.406
Bottom of Screens (m)	281.96	282.27	281.8614	282.912	282.406
EQUIPPING DETAILS					
Pump Type					
Pump Installation Date					
Pump Capacity (kL/day)					
Pump Suction/Inlet (m BTOC)					
Bottom of motor (m BTOC)					
Airline Length (m BTOC)	N/A	N/A	N/A	N/A	N/A
Available Drawdown (m)					
Comments					
PUMPING TEST RESULTS					
Date of Test					
Pump Test Rate (kL/day)	5,400	5,400	5,500	5,400	5,400
Specific Capacity (m^3/day/m)					
Recommended (kL/day)	17,743	17,774	17,698	8,980	8,879
Long-term Drawdown (m)	0.1	0.8	0.6	1.8	0.3
Comments					
ABSTRACTION					
Pumping 2020/21 (kL)	241,920	349,438	1,229,491	185,420	822,664
Hours Pumped	503	985	2631.8	870.1	2,587.2
Ave Output (kL/day)	11,543	8,514	11,212	5,114	7,631

BORE DETAILS			
Bore Number	PB6	PB7	PB8
Functional Location Number	W0026744	W0026745	W0026746
Date Drilled	Relined 2010	Relined 2013	17/07/1971
Bore Type	Production	Production	Production
Zone	50	50	50
MGA Easting	506804.3	508856.2	509142.3
MGA Northing	7611157.8	7610230.8	7609949
BORE CONSTRUCTION			
Casing Diameter (mm)	370	370	374
Casing Type	Stainless	Stainless	Stainless
Screen/Slot Interval (m BTOC)	10.30 - 19.30	16.25 - 25.3	15.72 - 24.53
Screen/Slots	Screen	Screen	Slots
Bore Depth (m BTOC)	19.3	25.3	25.17
SWL when drilled (m BTOC)	11.78	14.02	14.54
REDUCED LEVELS			
Height Datum	AHD	AHD	AHD
Top of Casing (m)	306.136	308.562	308.519
Bottom of Bore (m)	286.836	283.262	283.349
Top of Screens (m)	295.826	292.312	270.519
Bottom of Screens (m)	286.836	283.262	258.519
EQUIPPING DETAILS			
Pump Type	Turbine	Turbine	Turbine
Pump Installation Date			
Pump Capacity (kL/day)			
Pump Suction/Inlet (m BTOC)			
Bottom of motor (m BTOC)			
Airline Length (m BTOC)	N/A	N/A	N/A
Available Drawdown (m)			
Comments			
PUMPING TEST RESULTS			
Date of Test			
Pump Test Rate (kL/day)	5,400	5,500	5,500
Specific Capacity (m^3/day/m)			
Recommended (kL/day)	8,838	8,911	8,887
Long-term Drawdown (m)	0.3	Nil	Nil
Comments			
ABSTRACTION			
Pumping 2020/21 (kL)	612,264	0	0
Hours Pumped	2,130.5	0	0
Ave Output (kL/day)	6,897	0	0

BORE DETAILS				
Bore Number	1C	1E	2B	2C
Functional Location Number	W3000515	W3000519	W3000496	W3000494
Date Drilled	20/05/1968	3/08/1968	27/05/1968	27/07/1968
Bore Type	MAL 8	MAL 8	MAL 8	MAL 8
Zone	50	50	50	50
MGA Easting	506646.2	506833.8	495681	496755
MGA Northing	7608929.3	7612267.9	7610331.1	7607391.3
BORE CONSTRUCTION				
Casing Diameter (mm)	127	70	152	127
Casing Type		PVC		
Screen/Slot Interval (m BTOC)	12.34-18.40	6.0-12.0	22.70-28.92	27.32-42.18
Screen/Slots	Slotted	Slotted	Slotted	Slotted
Bore Depth (m BTOC)	28.96	12	28.92	42.18
SWL when drilled (m BTOC)	10.97	5.95	21.44	23.39
REDUCED LEVELS				
Height Datum	AHD	AHD	AHD	AHD
Top of Casing (m)	305.11	300.17	315.59	317.17
Bottom of Bore (m)	276.15	288.17	286.67	274.99
Top of Screens (m)	292.77	294.17	292.89	289.85
Bottom of Screens (m)	286.71	288.17	286.67	274.99

BORE DETAILS				
Bore Number	4A	5B	7A	7C
Functional Location Number	W3000490	W3000525	W3000504	W3000508
Date Drilled	8/07/1968	28/09/1968	2/08/1968	29/07/1968
Bore Type	MAL 8	MAL 8	MAL 8	MAL 8
Zone	50	50	50	50
MGA Easting	490202.3	512299	502091.6	501958.8
MGA Northing	7604680.8	7603546.3	7612993.8	7608243.9
BORE CONSTRUCTION				
Casing Diameter (mm)	152	152	127	127
Casing Type				
Screen/Slot Interval (m)	22.86-28.96	22.50-28.60	15.24-27.43	18.90-37.19
Screen/Slots	Slotted	Slotted	Slotted	Slotted
Bore Depth (mbtoc)	28.96	28.6	29.46	37.19
SWL when drilled (mbtoc)	22.94	19.66	14.93	22.1
REDUCED LEVELS				
Height Datum	AHD	AHD	AHD	AHD
Top of Casing (m)	316.67	313.8	308.71	315.9
Bottom of Bore (m)	287.71	285.2	279.25	278.71
Top of Screens (m)	293.81	291.3	293.47	297
Bottom of Screens (m)	287.71	285.2	281.28	278.71

BORE DETAILS				
Bore Number	8C	P2	P8	P2/77
Functional Location Number	W3000484	W3000502	W3000498	W3000541
Date Drilled	11/08/1968	14/10/1975	18/10/1975	22/09/1977
Bore Type	MAL 8	Palm Creek	Palm Creek	Delta
Zone	50	50	50	50
MGA Easting	488845.4	496044.7	496657.3	505704
MGA Northing	7602297.9	7614547.3	7613446	7614139
BORE CONSTRUCTION				
Casing Diameter (mm)	152			
Casing Type		PVC	PVC	PVC
Screen/Slot Interval (m)	24.69-31.39	4.00-9.00	13.1-19.1	3.48-18.37
Screen/Slots	Slotted	Slotted	Slotted	Slotted
Bore Depth (mbtoc)	31.39	9	19.1	18.37
SWL when drilled (mbtoc)	23.67	3.86	14.26	3.57
REDUCED LEVELS				
Height Datum	AHD	AHD	AHD	AHD
Top of Casing (m)	317.59	282.55	306.72	282.53
Bottom of Bore (m)	286.2	273.55	306.72	264.16
Top of Screens (m)	292.9	278.55	293.62	279.05
Bottom of Screens (m)	286.2	273.55	287.62	264.16

BORE DETAILS				
Bore Number	P3/77	P4/78	03/04	12/04
Functional Location Number	W3000545	W3000547	W3001099	W3001108
Date Drilled	23/09/1977	21/09/1978	21/11/2004	28/11/2004
Bore Type	Delta	Delta	Delta	Delta
Zone	50	50	50	50
MGA Easting	506327	506313.6	507106	507602.9
MGA Northing	7614469.6	7613855.5	7613720.2	7613941.5
BORE CONSTRUCTION				
Casing Diameter (mm)		40	53.7	53.7
Casing Type	PVC	PVC	PVC	PVC
Screen/Slot Interval (m)	1.84-12.93	0.45 – 6.00	2.00-5.00	1.14-3.14
Screen/Slots	Slotted	Slotted	0.5 mm Slots	0.5 mm Slots
Bore Depth (mbtoc)	12.93	6	5	3.14
SWL when drilled (mbtoc)	2.32	2.82	1.6	1.06
REDUCED LEVELS				
Height Datum	AHD	AHD	AHD	AHD
Top of Casing (m)	279.96	285.44	287.22	285.15
Bottom of Bore (m)	267.03	279.44	282.22	282.01
Top of Screens (m)	278.12	284.99	285.22	284.01
Bottom of Screens (m)	267.03	279.44	282.22	282.01

BORE DETAILS				
Bore Number	04/04	P8/77	P7/78	08/04
Functional Location Number	W3001100	W3000529	W3000761	W3001104
Date Drilled	21/11/2004	29/09/1977	25/09/1978	22/11/2004
Bore Type		Riverine Monitoring	Riverine Monitoring	Riverine Monitoring
Zone	50	50	50	50
MGA Easting	507036	510931.6	510819	512494
MGA Northing	7613190	7610195.5	7610096.6	7607958
BORE CONSTRUCTION				
Casing Diameter (mm)	53.7			53.7
Casing Type	PVC	PVC	PVC	PVC
Screen/Slot Interval (m)	1.50-5.00	1.6-6.5	0.75-3.07	2.90-6.50
Screen/Slots	0.5 mm Slots	Slots	Slotted	0.5 mm Slots
Bore Depth (mbtoc)	5	6.5	3.07	6.5
SWL when drilled (mbtoc)	2	2.26	2.47	2.5
REDUCED LEVELS				
Height Datum	AHD	AHD	AHD	AHD
Top of Casing (m)	289.39	296.4	296.87	297.14
Bottom of Bore (m)	284.39	289.9	293.8	290.64
Top of Screens (m)	287.89	294.8	296.12	294.24
Bottom of Screens (m)	284.39	289.9	293.8	290.64
BORE DETAILS				
Bore Number	P10 (DoW	P7/77	P9A/78	
Functional Location Number	W3013776	W3000535	W3000533	
Date Drilled	23/09/1975	28/09/1977	25/09/1978	
Bore Type	Monitoring	Monitoring	Monitoring	
Zone	50	50	50	
MGA Easting	503638	511160.5	511988.1	
MGA Northing	7615056	7610701.6	7608650.2	
BORE CONSTRUCTION				
Casing Diameter (mm)			40	
Casing Type	PVC	PVC	PVC	
Screen/Slot Interval (m)	Slotted	1.68-6.88	1.3-2.8	
Screen/Slots	3.13-13.43	Slotted	Slotted	
Bore Depth (mbtoc)	13.43	6.88	2.8	
SWL when drilled (mbtoc)	3.80	2.88	2.16	
REDUCED LEVELS				
Height Datum	AHD	AHD		
Top of Casing (m)	274.5	293.46		
Bottom of Bore (m)	261.07	286.58		
Top of Screens (m)	271.37	291.58		
Bottom of Screens (m)	261.07	286.58		

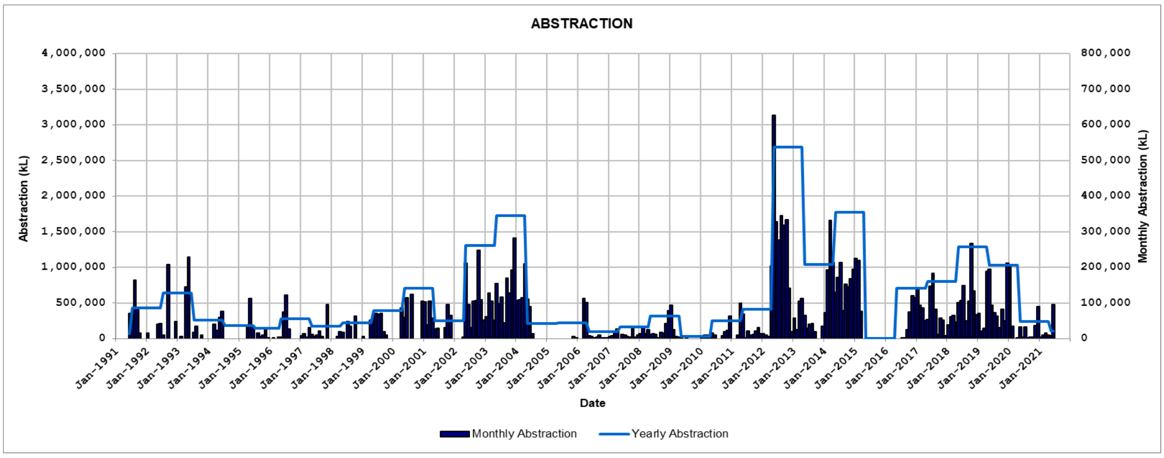
APPENDIX C
Monthly Abstraction Over Review Period

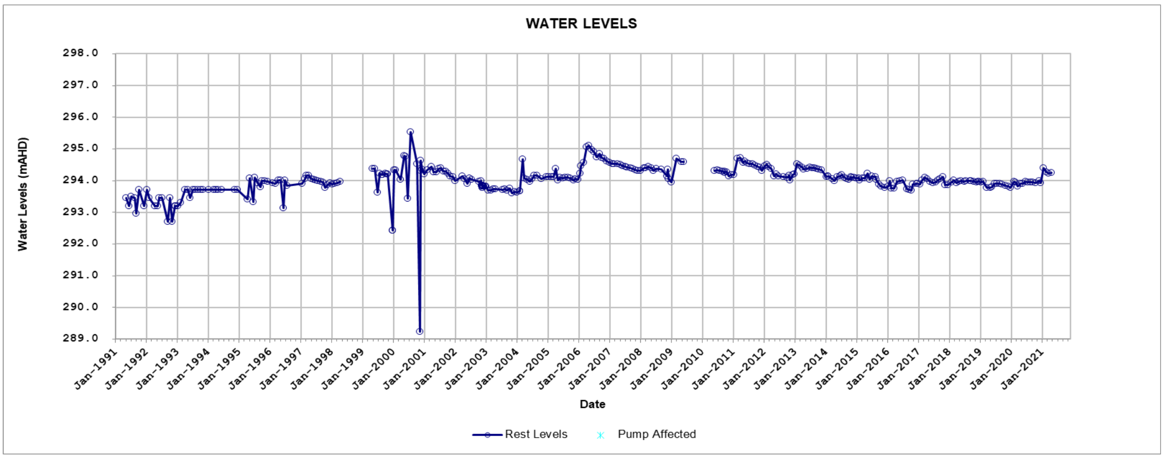
Water Year		Millstream Bore 1 (kL)	Millstream Bore 2 (kL)	Millstream Bore 3 (kL)	Millstream Bore 4 (kL)	Millstream Bore 5 (kL)	Millstream Bore 6 (kL)	Annual Total (kL)
2018 / 2019	May	117,000	110,763	106,387	84,307	37,151	0	455,608
	Jun	109,000	75,006	80,723	58,398	159,773	0	482,900
	Jul	145,000	84,734	109,271	109,678	41,630	0	490,313
	Aug	42,000	14,549	32,156	2,280	10,981	0	101,966
	Sep	20,000	6,084	4,503	5,897	4,263	0	40,747
	Oct	18,000	2,268	72,516	2,613	6,516	0	101,913
	Nov	20,000	1,132	630	1,415	14,950	0	38,127
	Dec	2,000	409	21	0	697	0	3,127
	Jan	25,000	3,105	251	3,318	21,076	0	52,750
	Feb	7,000	6,392	337	18	565	0	14,312
	Mar	35,000	24,092	31,687	45,833	17,630	0	154,242
	Apr	179,000	93,684	57,234	110,981	133,003	49,850	623,752
	Total	**719,000**	**422,218**	**495,716**	**424,738**	**448,235**	**49,850**	**2,559,757**
2019 / 2020	May	194,995	49,746	3,907	245,889	108,069	94,982	697,588
	Jun	93,725	35,820	73,392	113,225	102,570	40,117	458,849
	Jul	71,499	12,420	34,497	44,144	58,261	5,732	226,553
	Aug	63,342	35,386	3,865	64,641	35,734	28,612	231,580
	Sep	31,059	27,441	7,341	39,049	28,756	13,289	146,935
	Oct	81,132	64,531	25,168	77,575	102,277	65,368	416,051
	Nov	49,509	116,207	16,532	11,347	63,908	59,837	317,340
	Dec	211,543	154,460	9,886	0	42,089	66,652	484,630
	Jan	202,411	203,702	14,235	0	107,410	77,390	605,148
	Feb	33,391	199,983	90,233	0	122,914	72,647	519,168
	Mar	0	149,144	176,693	132,863	136,401	109,946	705,047
	Apr	169	179,280	207,425	154,471	179,430	99,177	819,952
	Total	**1,032,775**	**1,228,120**	**663,174**	**883,204**	**1,087,819**	**733,749**	**5,628,841**
2020 / 2021	May	32,294	75,943	206,183	0	139,291	120,062	573,773
	Jun	3,727	24,669	264,600	0	118,397	74,527	485,920
	Jul	33,086	19,279	94,889	0	59,249	49,259	255,762
	Aug	460	8,385	64,942	0	30,768	22,180	126,735
	Sep	3,750	37,700	27,238	0	16,736	7,791	93,215
	Oct	4,579	8,439	18,645	0	12,590	1,921	46,174
	Nov	36,184	51,917	38,147	0	34,621	39,235	200,104
	Dec	90,312	39,398	221,760	1,067	154,472	159,924	666,933
	Jan	3,822	823	225,597	198,219	138,353	66,097	632,911
	Feb	8,934	11,138	29,355	83,379	55,878	40,833	229,517
	Mar	15,276	46,529	37,044	10,421	48,810	10,833	168,913
	Apr	9,496	25,218	1,091	2,085	13,499	19,602	70,991
	Total	**241,920**	**349,438**	**1,229,491**	**295,171**	**822,664**	**612,264**	**3,550,948**

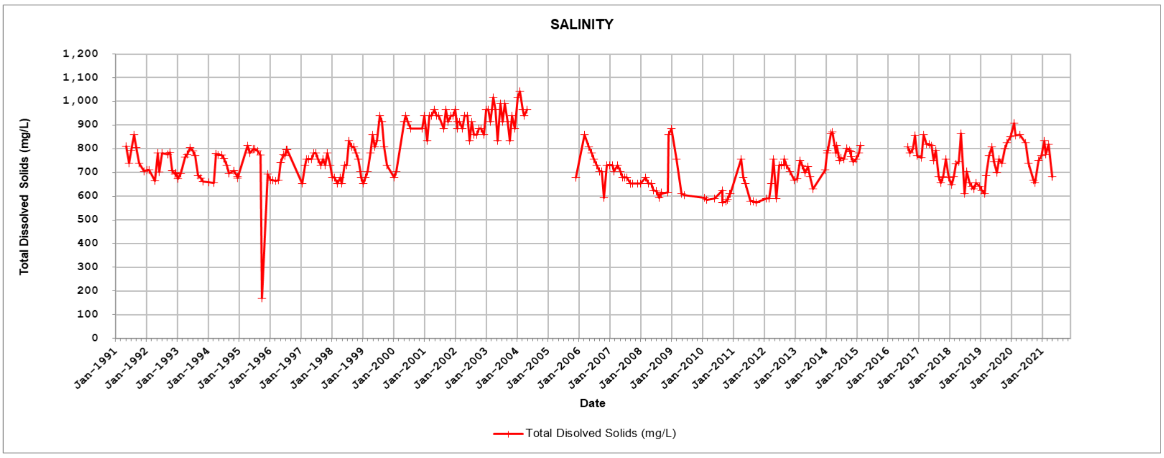
Water Year		Harding Dam (kL)	Annual Total (kL)
2018 / 2019	May	195,597	195,597
	Jun	0	0
	Jul	32,227	32,227
	Aug	450,918	450,918
	Sep	508,615	508,615
	Oct	736,644	736,644
	Nov	684,949	684,949
	Dec	621,738	621,738
	Jan	727,722	727,722
	Feb	478,868	478,868
	Mar	373,368	373,368
	Apr	22,229	22,229
	Total	**4,832,875**	**4,832,875**
2019 / 2020	May	10,568	10,568
	Jun	18,659	18,659
	Jul	429,578	429,578
	Aug	336,419	336,419
	Sep	492,502	492,502
	Oct	216,274	216,274
	Nov	7,221	7,221
	Dec	10,092	10,092
	Jan	142	142
	Feb	17	17
	Mar	4,906	4,906
	Apr	14,888	14,888
	Total	**1,541,266**	**1,541,266**
2020 / 2021	May	29,229	29,229
	Jun	117,353	117,353
	Jul	381,018	381,018
	Aug	471,019	471,019
	Sep	628,450	628,450
	Oct	622,464	622,464
	Nov	436,148	436,148
	Dec	8,622	8,622
	Jan	24,671	24,671
	Feb	513,186	513,186
	Mar	774,013	774,013
	Apr	315,000	315,000
	Total	**4,321,173**	**4,321,173**

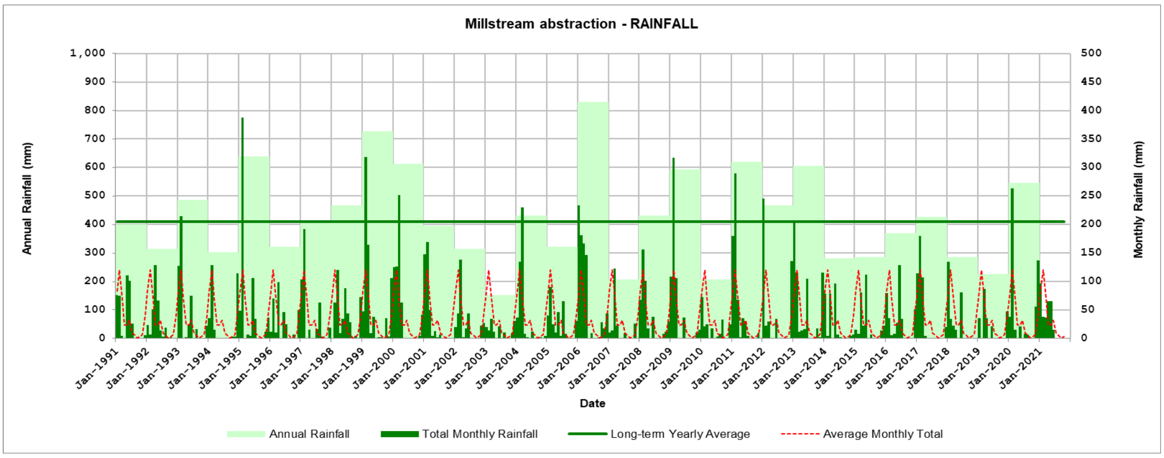
APPENDIX D
Production Bore Hydrographs

Millstream Bore 1

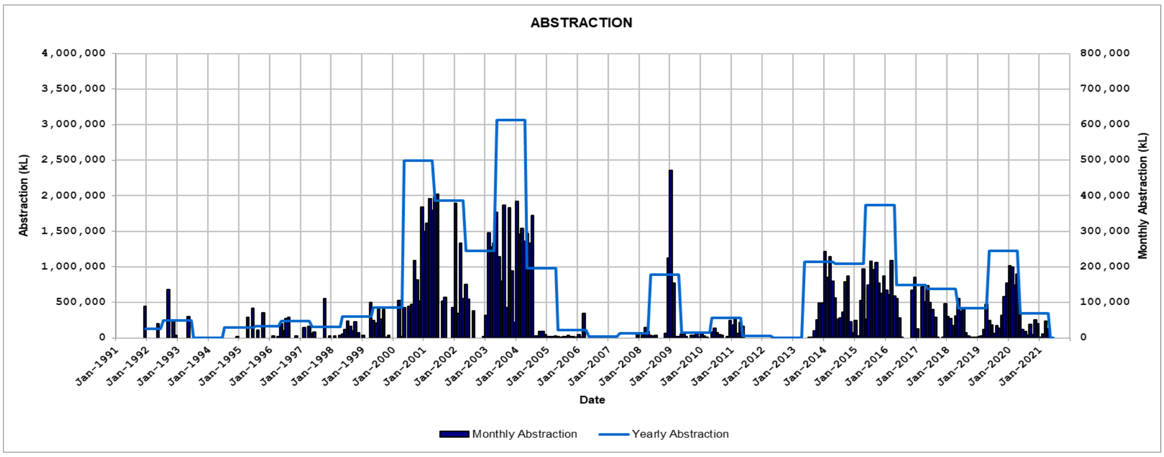


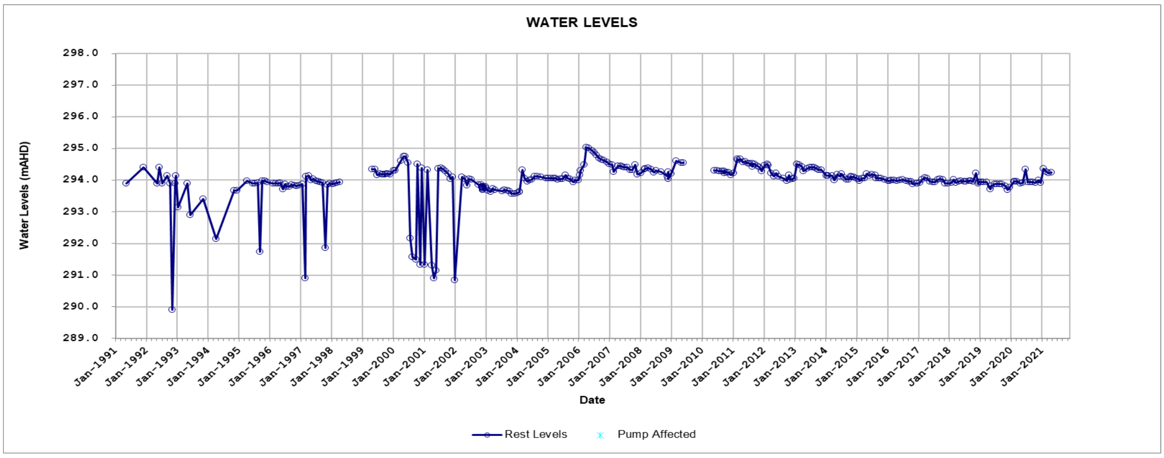


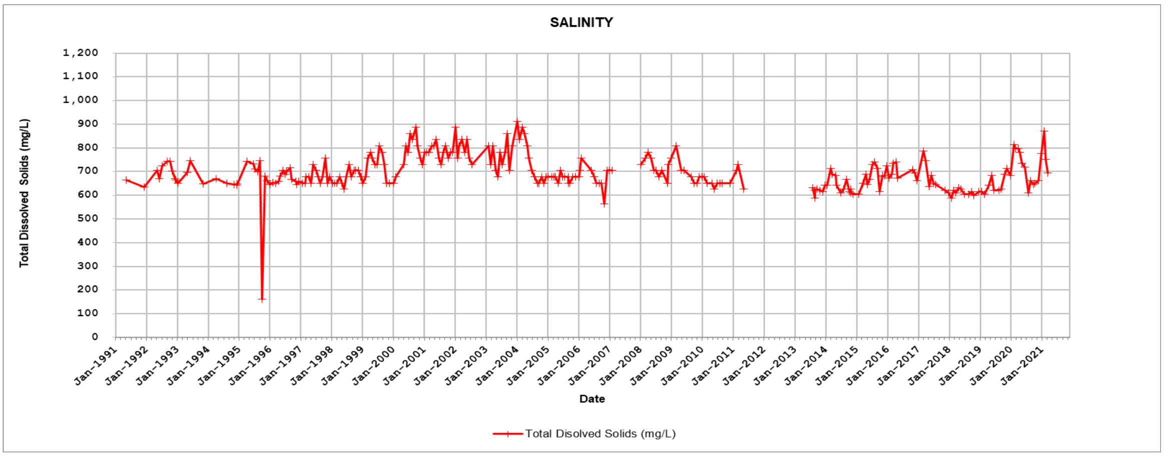


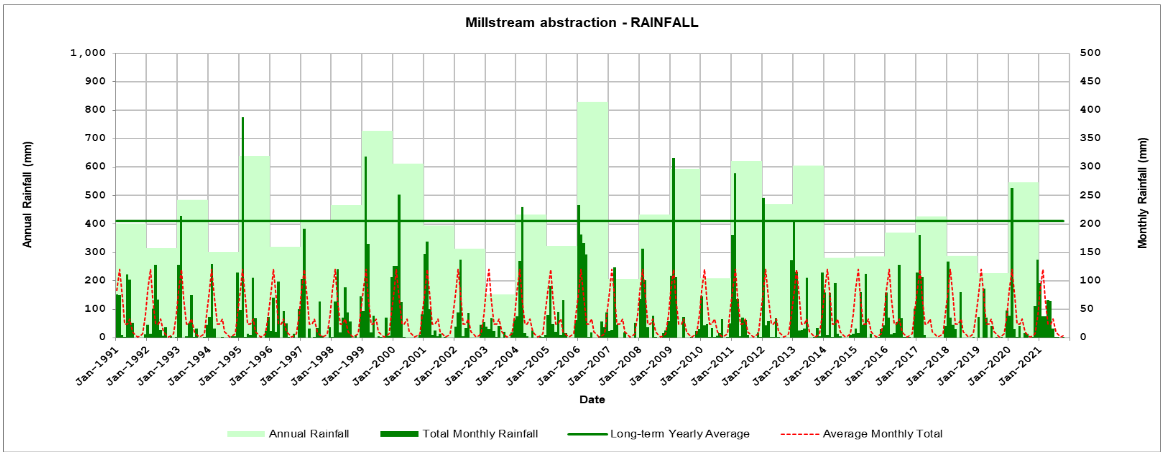


Millstream Bore 2

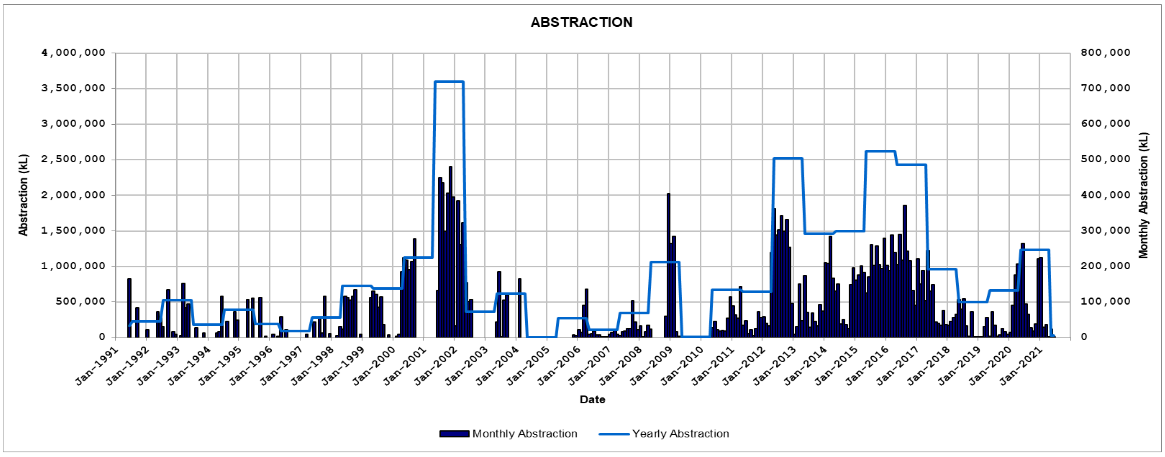


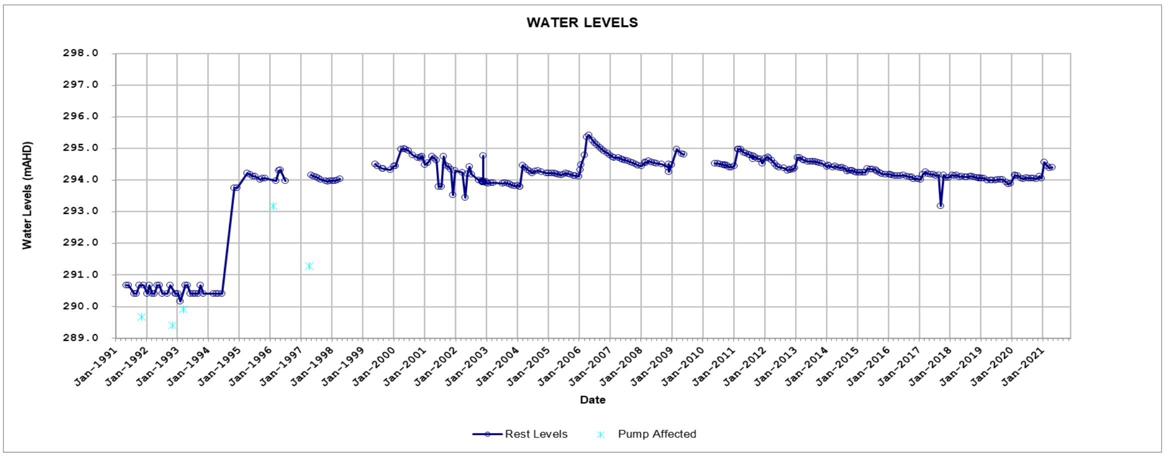


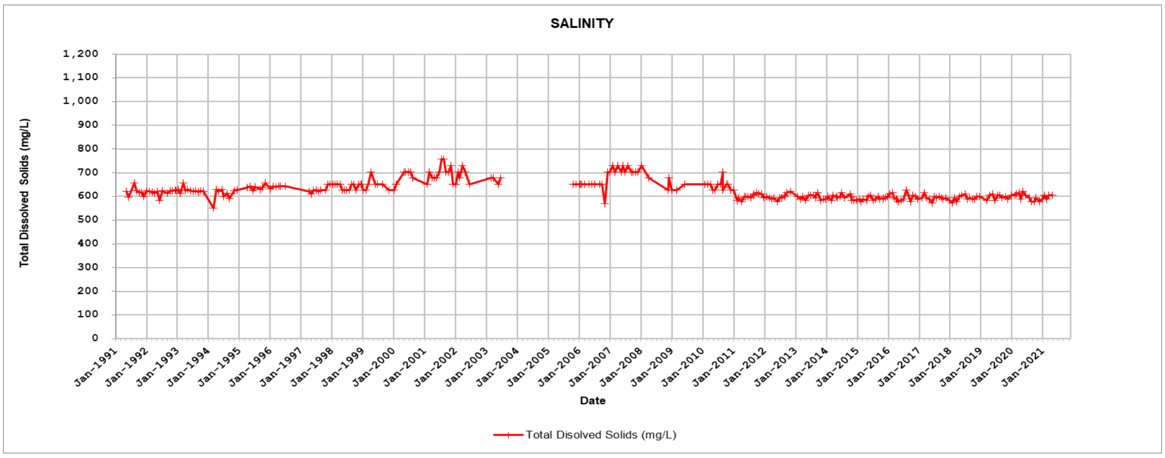


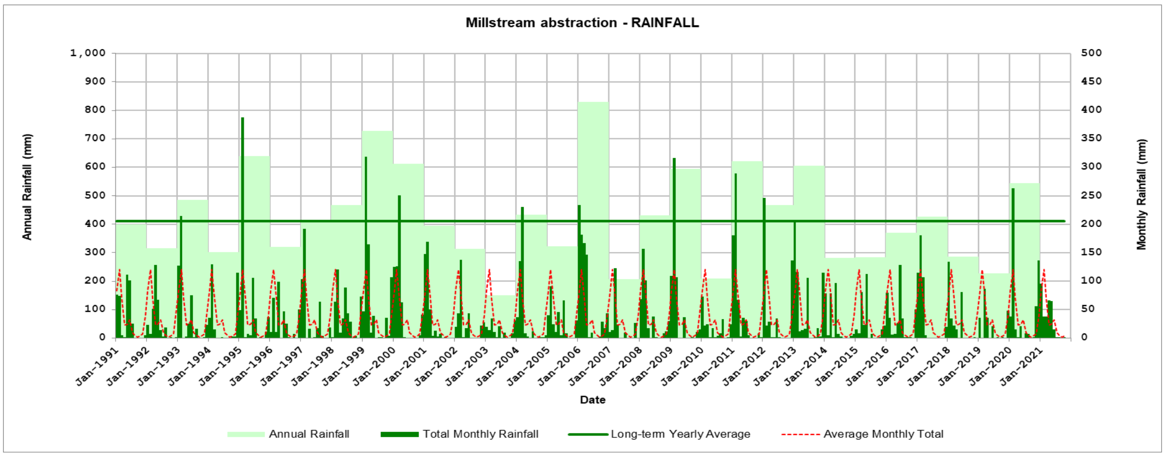


Millstream Bore 3

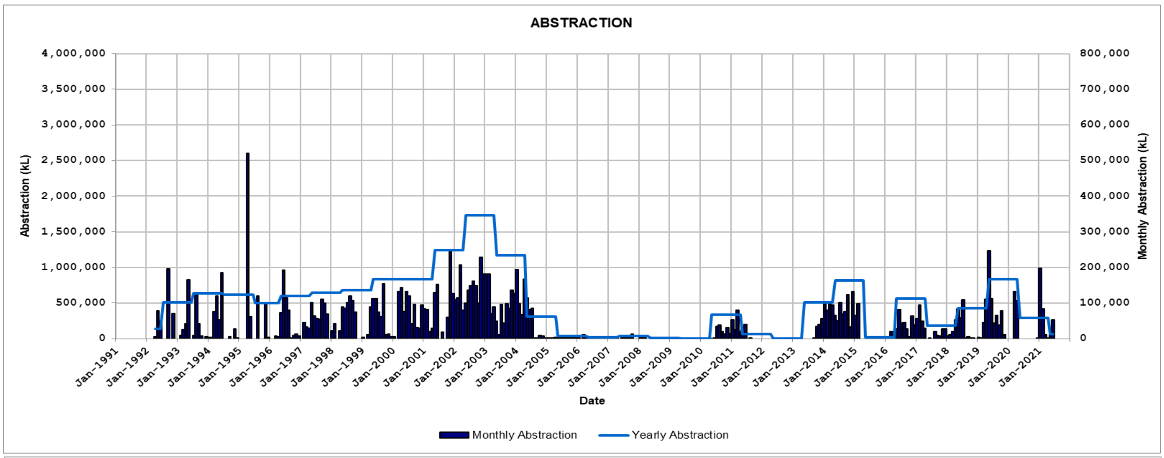


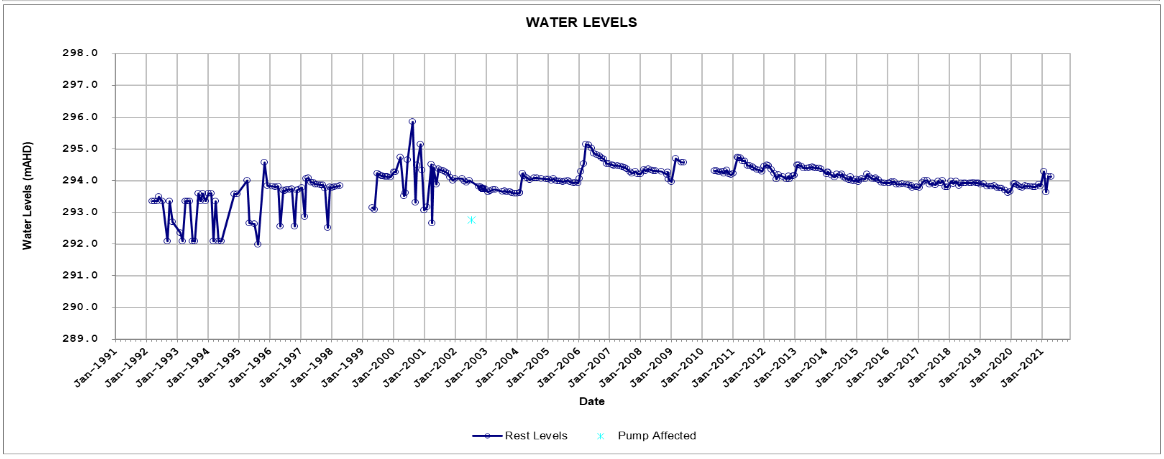


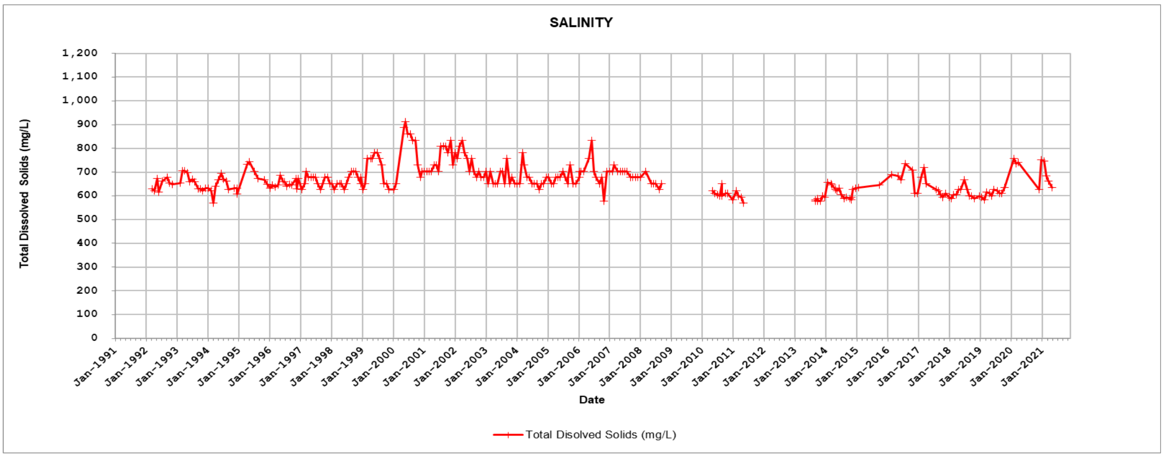


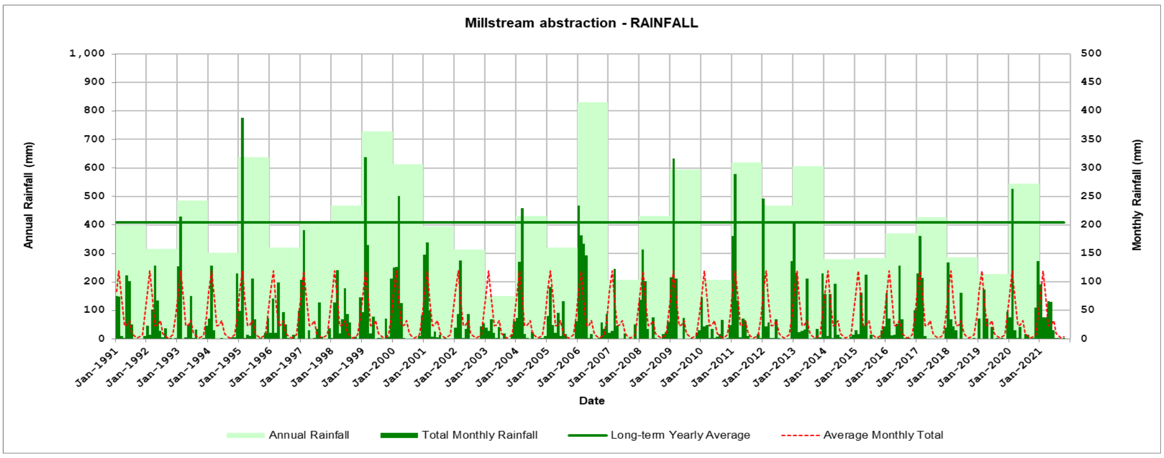


Millstream Bore 4

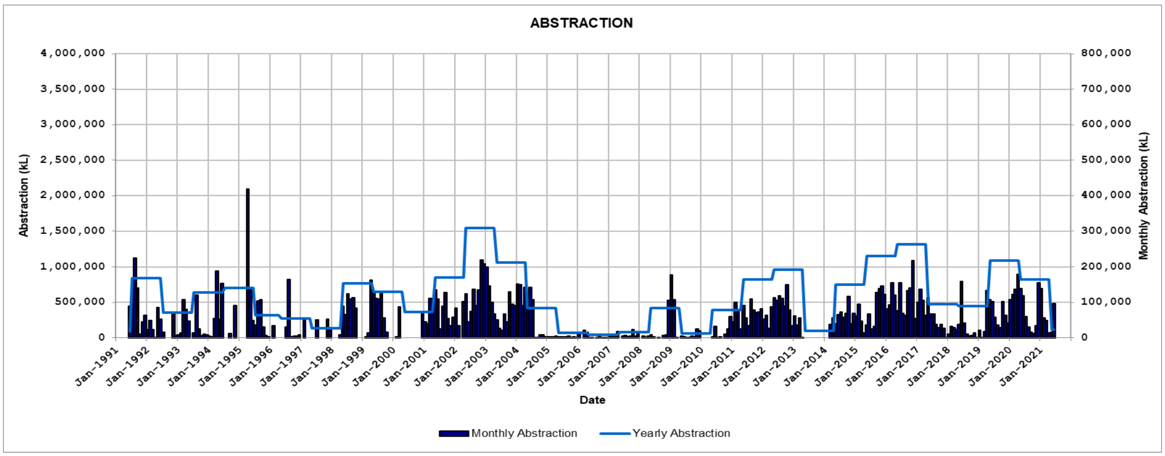


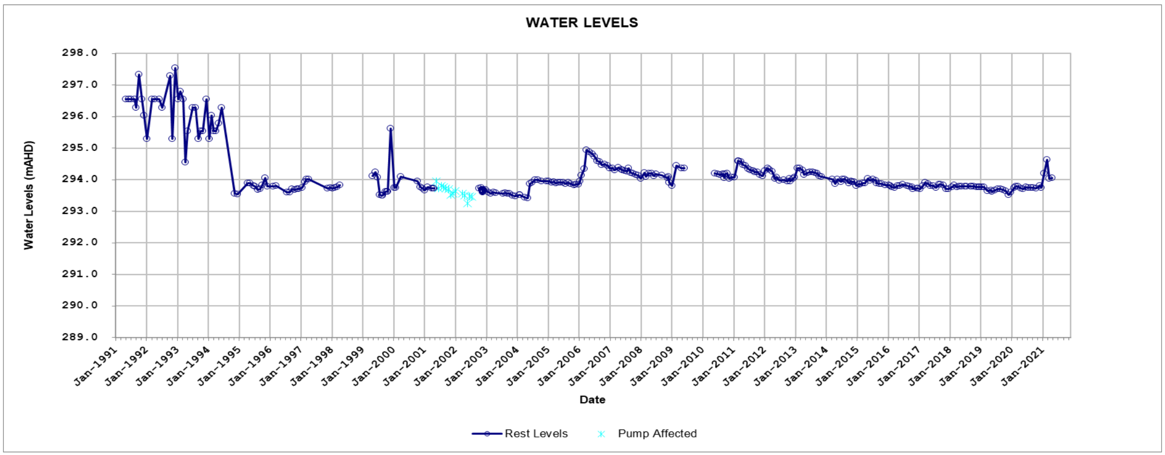


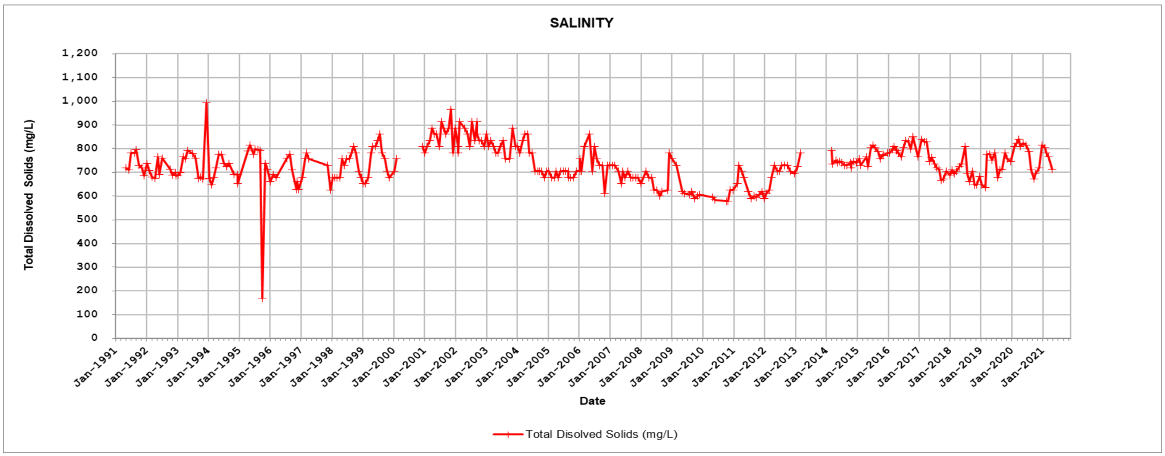


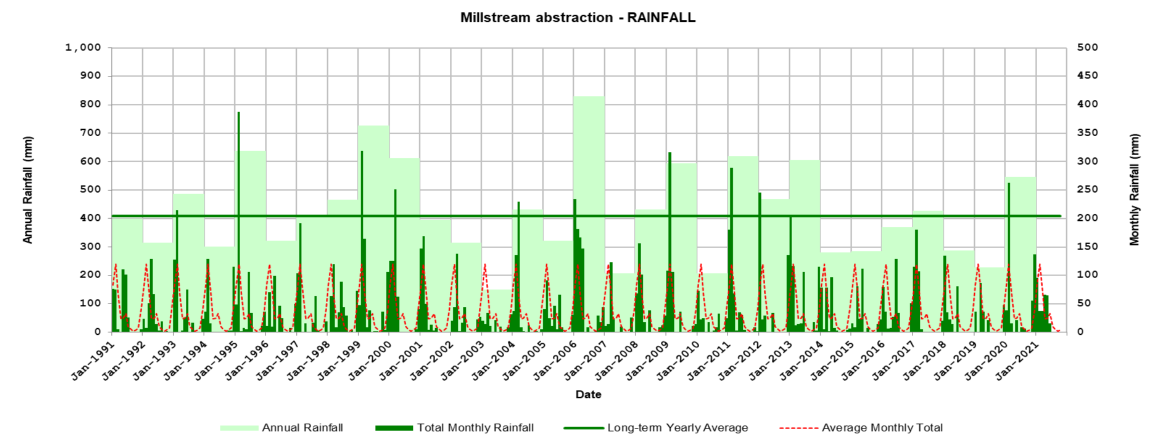


Millstream Bore 5

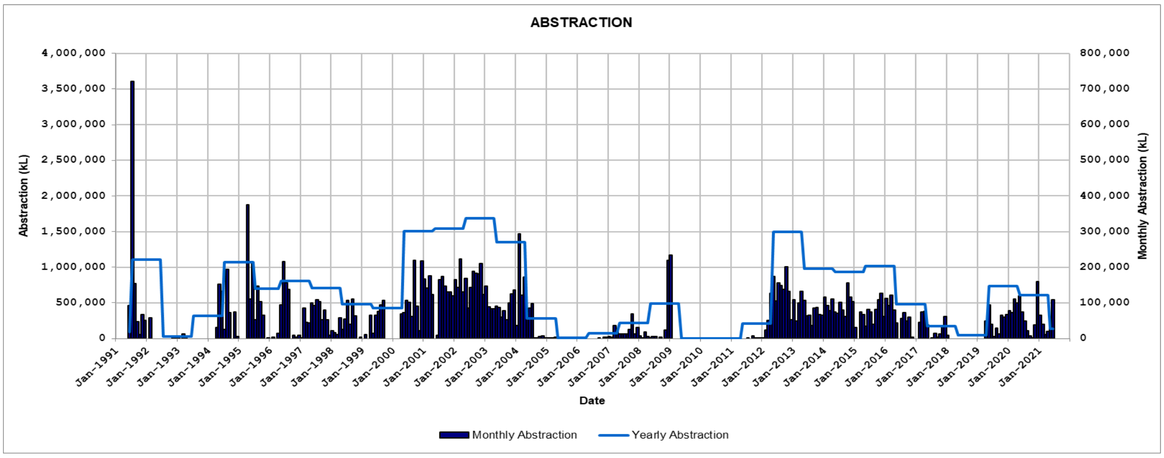


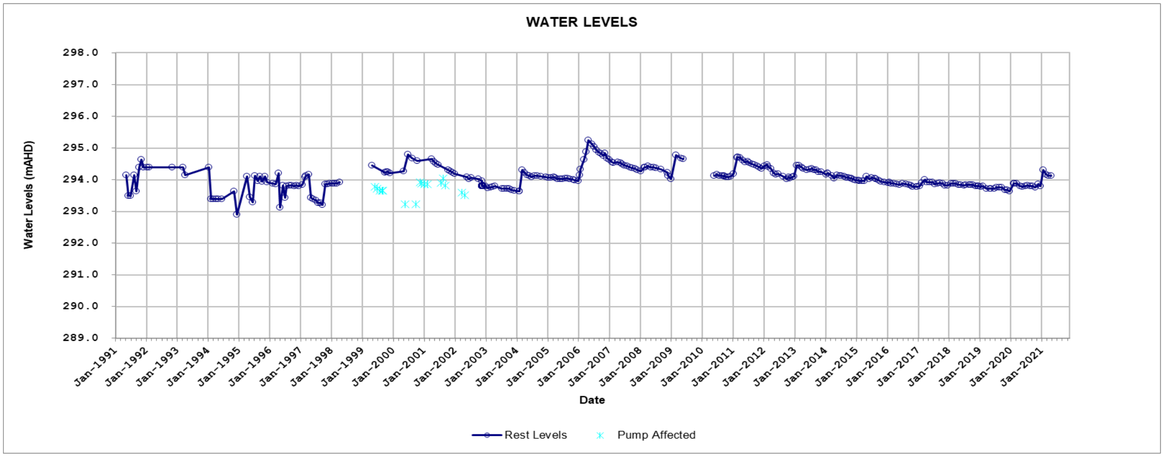


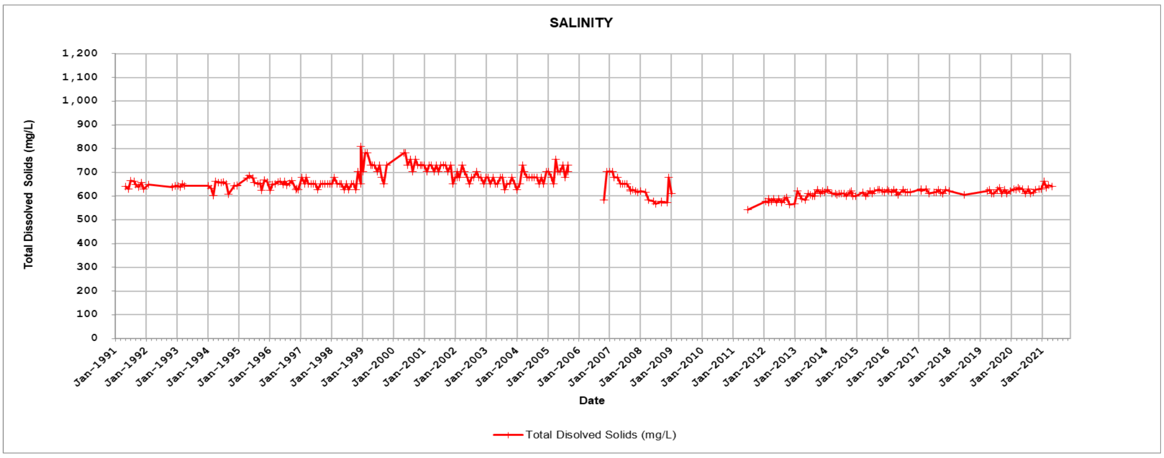


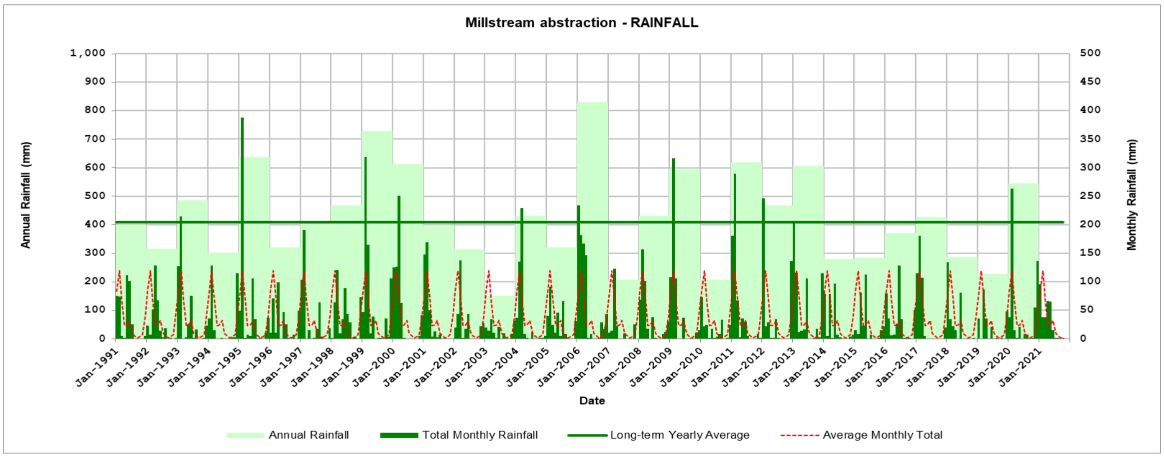


Millstream Bore 6

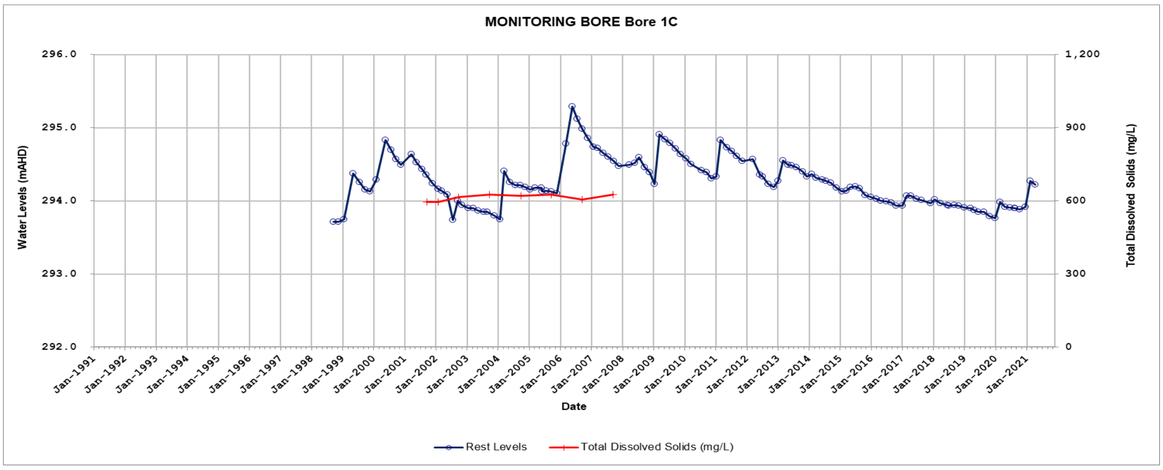


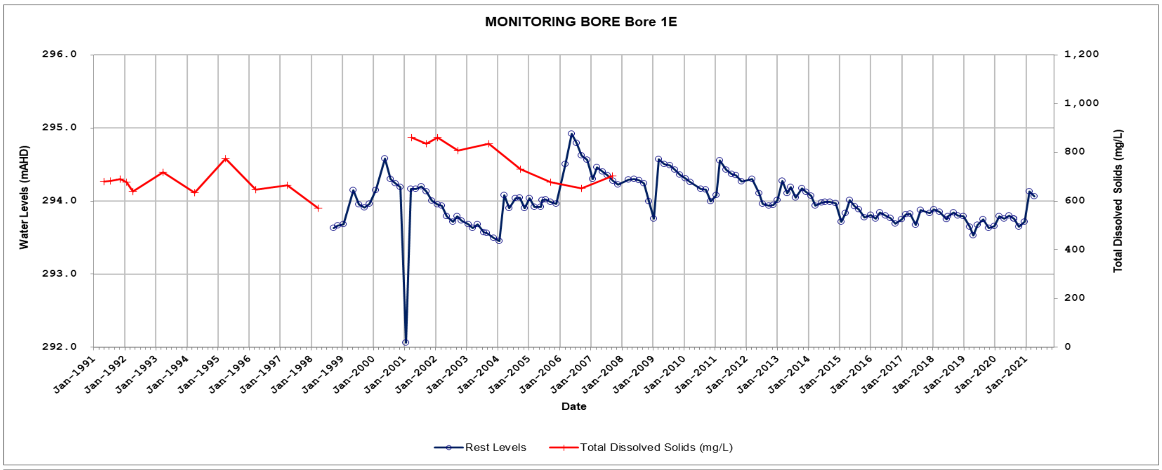


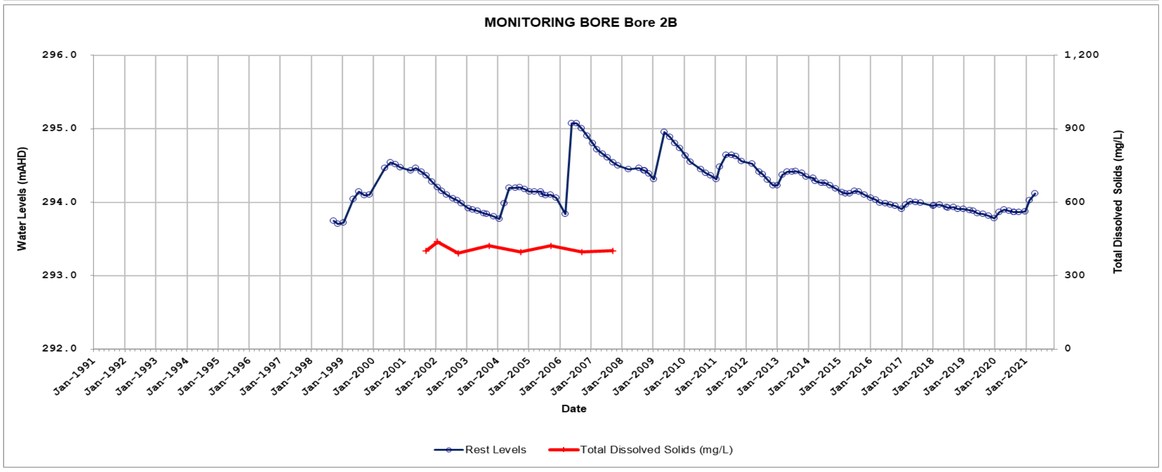


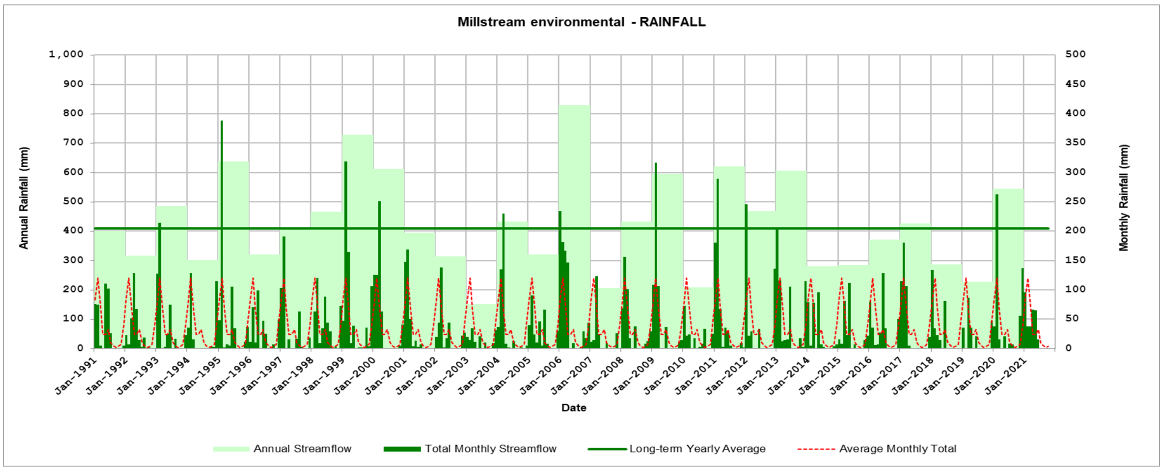


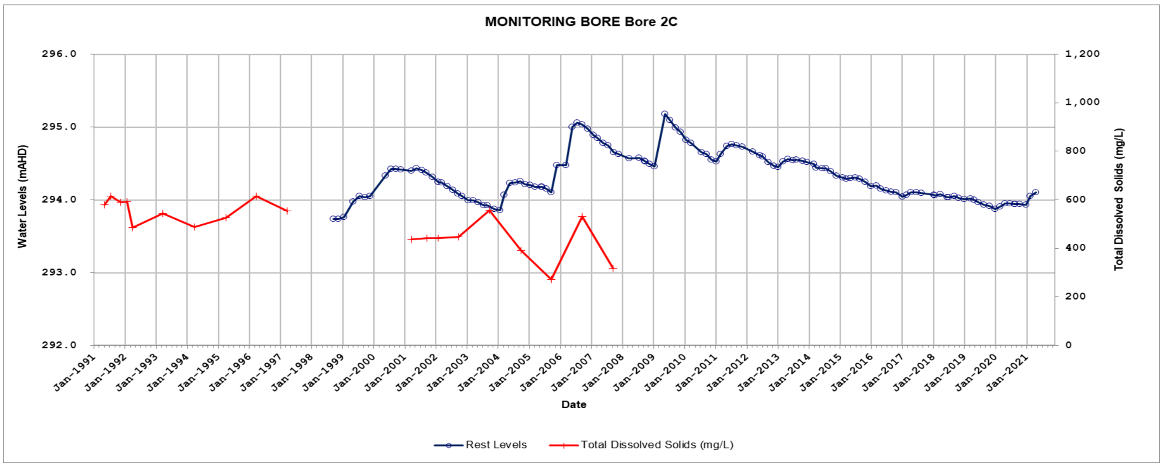
APPENDIX E
Monitoring Bore Hydrographs

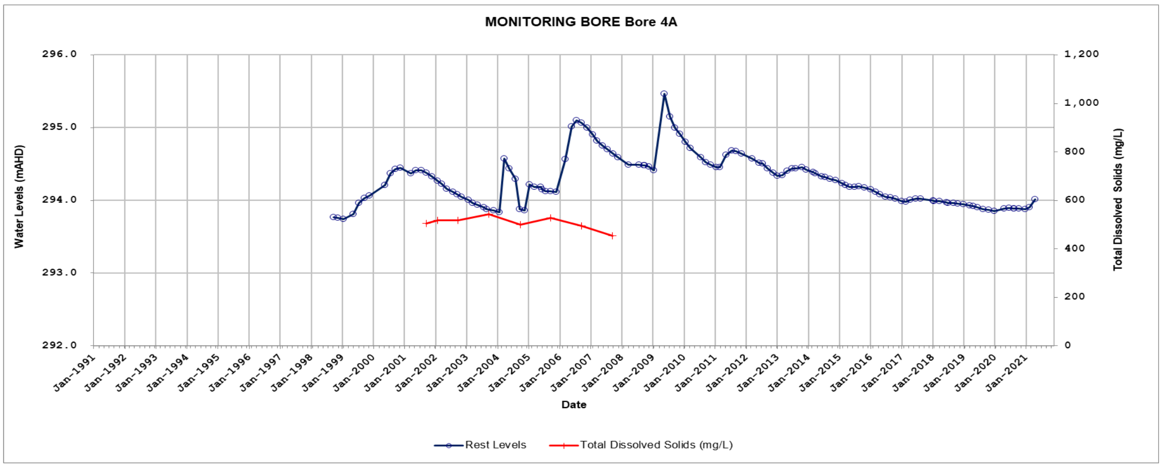

MONITORING BORE Bore 1C
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

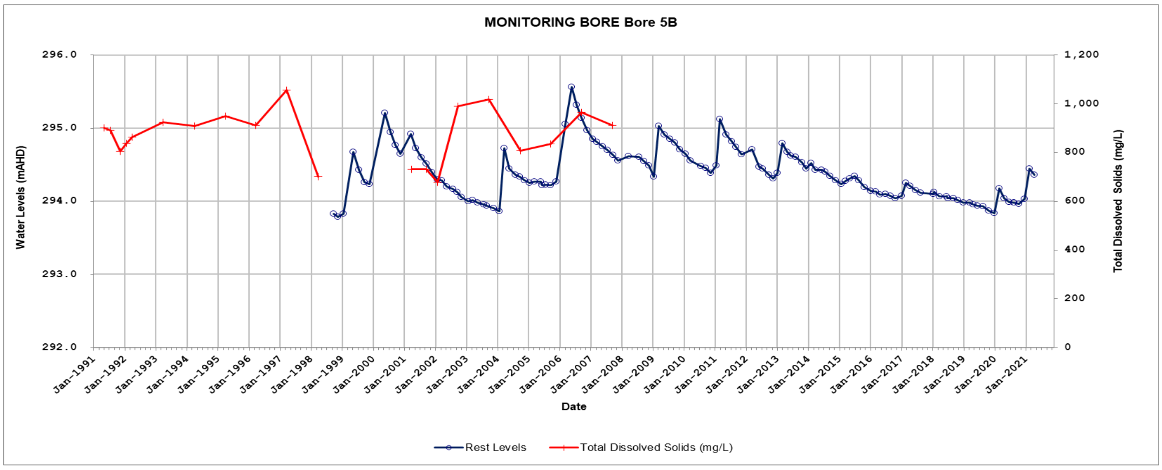

MONITORING BORE Bore 1E
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

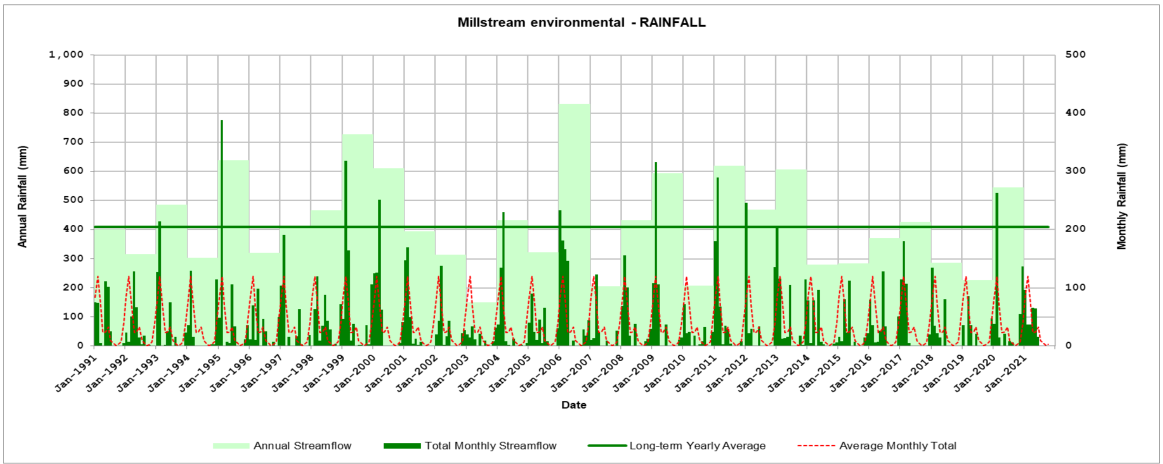

MONITORING BORE Bore 2B
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

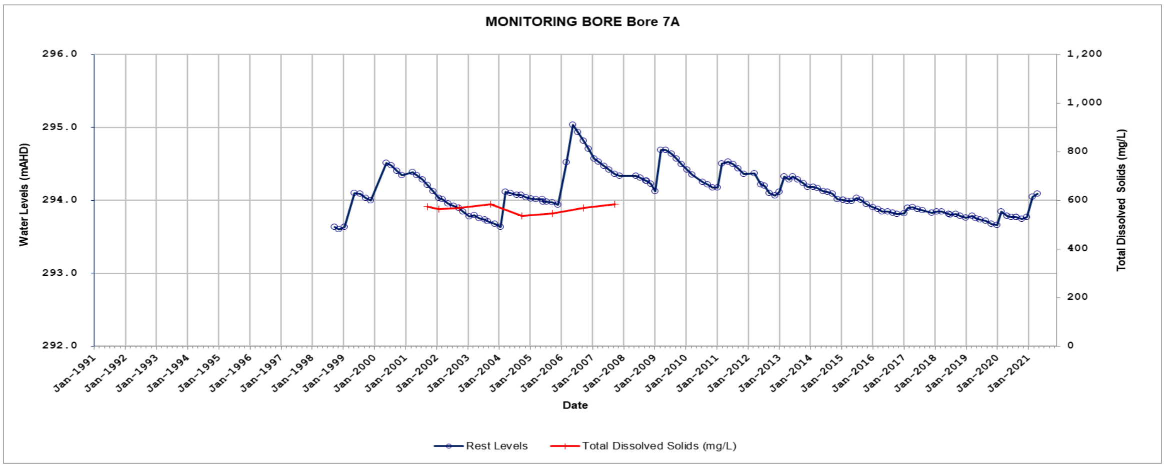

Millstream environmental - RAINFALL
Annual Rainfall (mm)
Monthly Rainfall (mm)
Date
Annual Streamflow
Total Monthly Streamflow
Long-term Yearly Average
Average Monthly Total

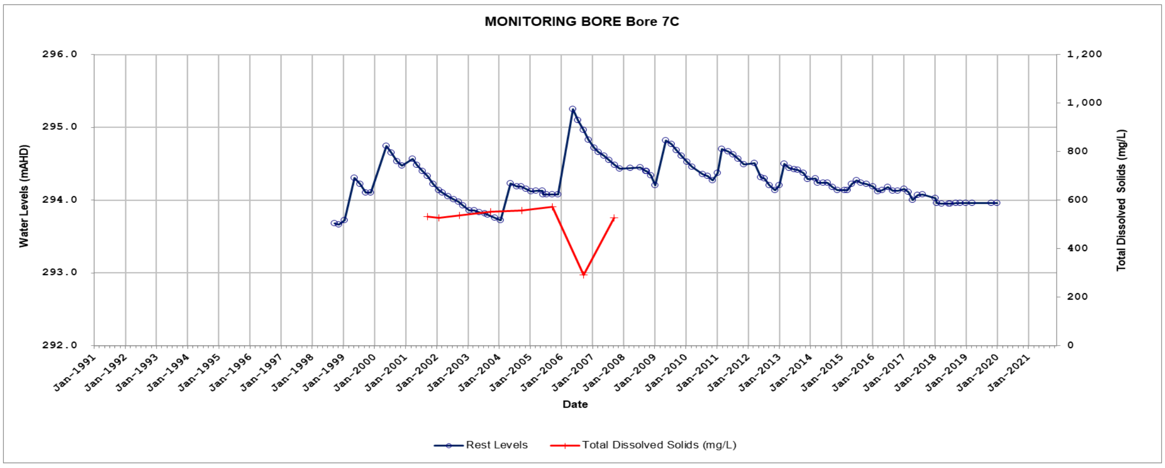

MONITORING BORE Bore 2C
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

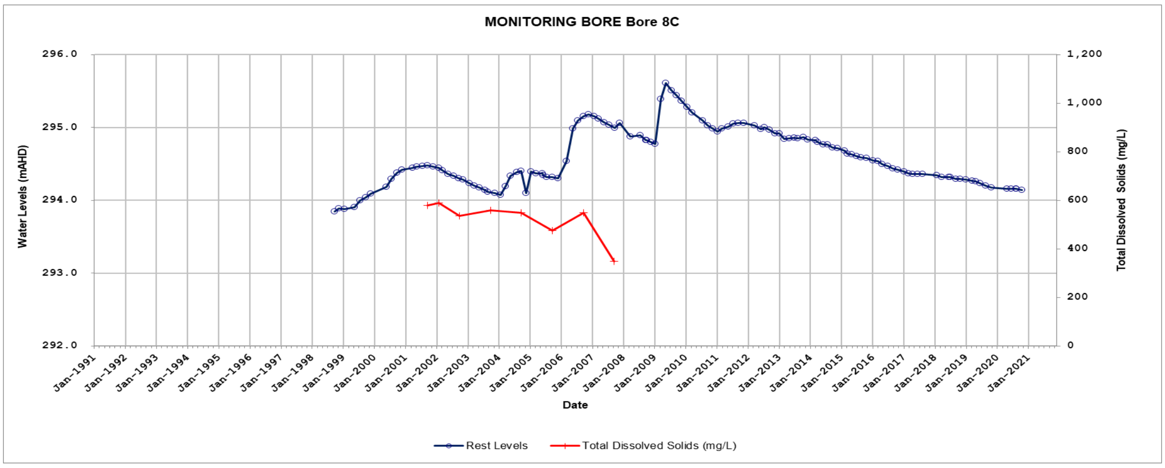

MONITORING BORE Bore 4A
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

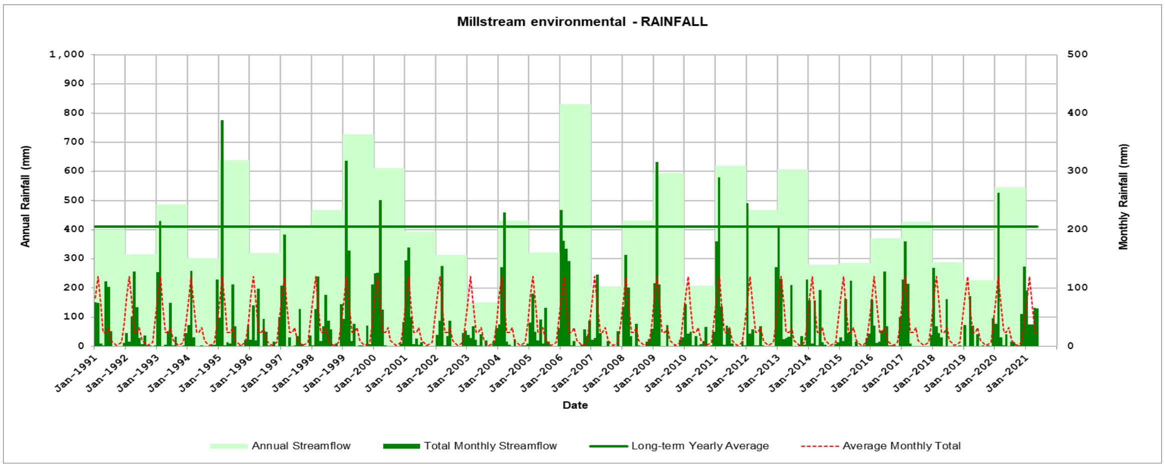

MONITORING BORE Bore 5B
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

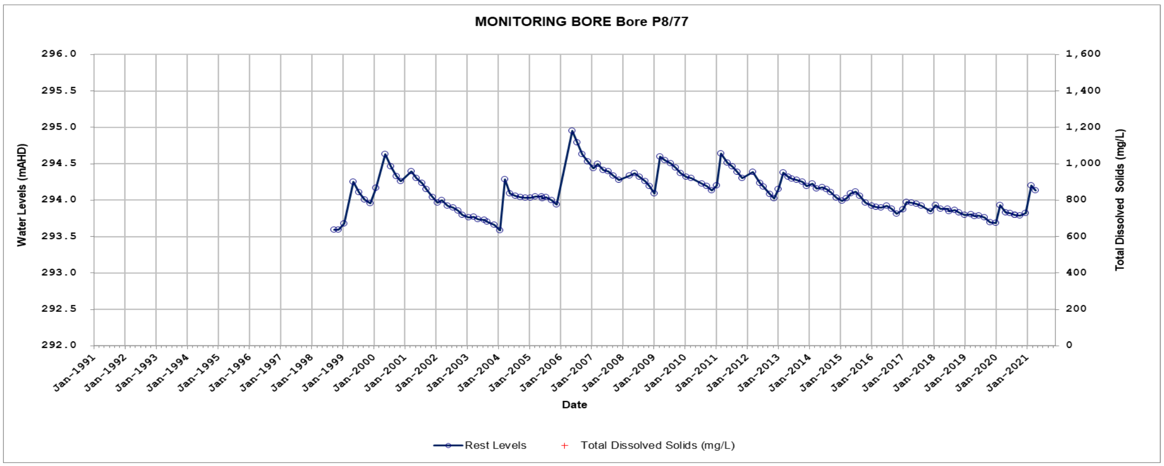

Millstream environmental - RAINFALL
Annual Rainfall (mm)
Monthly Rainfall (mm)
Date
Annual Streamflow
Total Monthly Streamflow
Long-term Yearly Average
Average Monthly Total

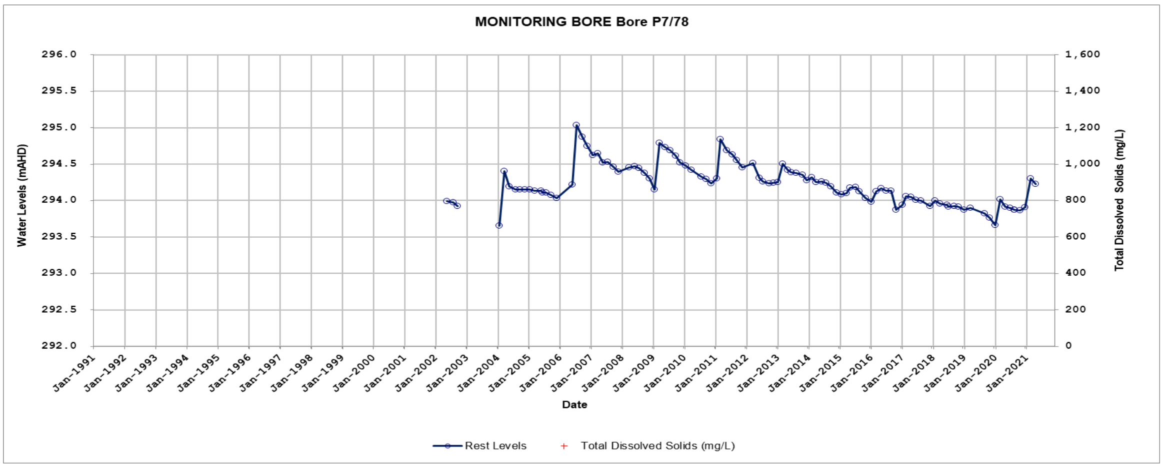

MONITORING BORE Bore 7A
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

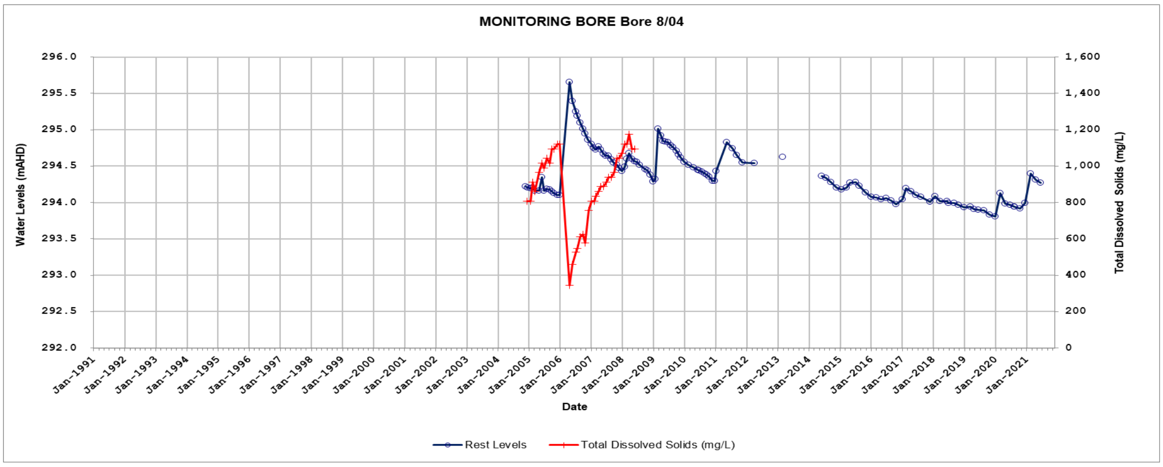

MONITORING BORE Bore 7C
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

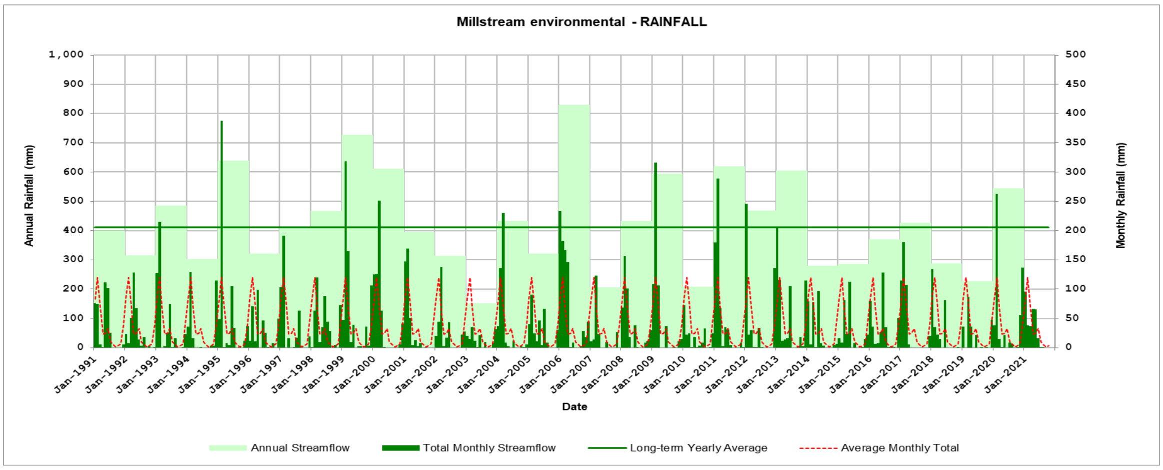

MONITORING BORE Bore 8C
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

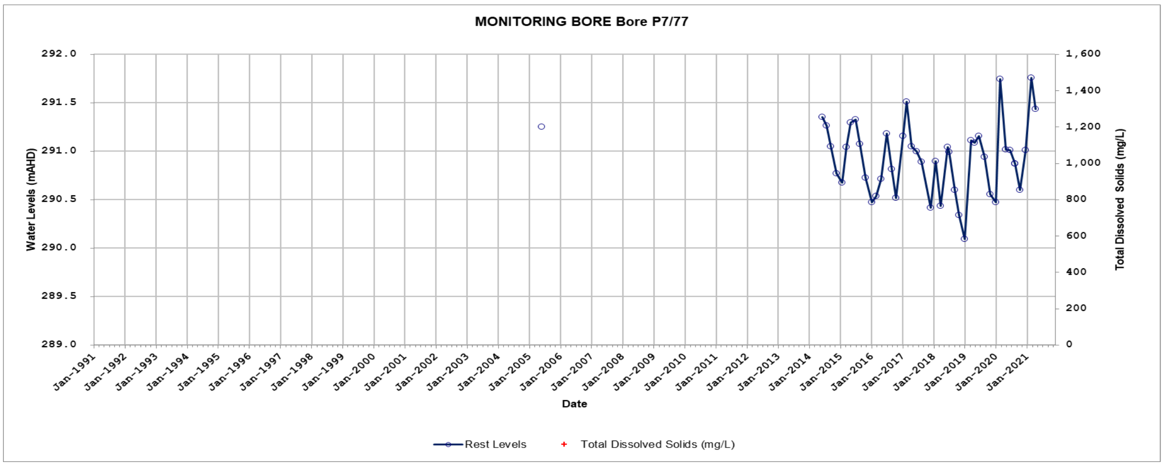

Millstream environmental - RAINFALL
Annual Rainfall (mm)
Monthly Rainfall (mm)
Date
Annual Streamflow
Total Monthly Streamflow
Long-term Yearly Average
Average Monthly Total

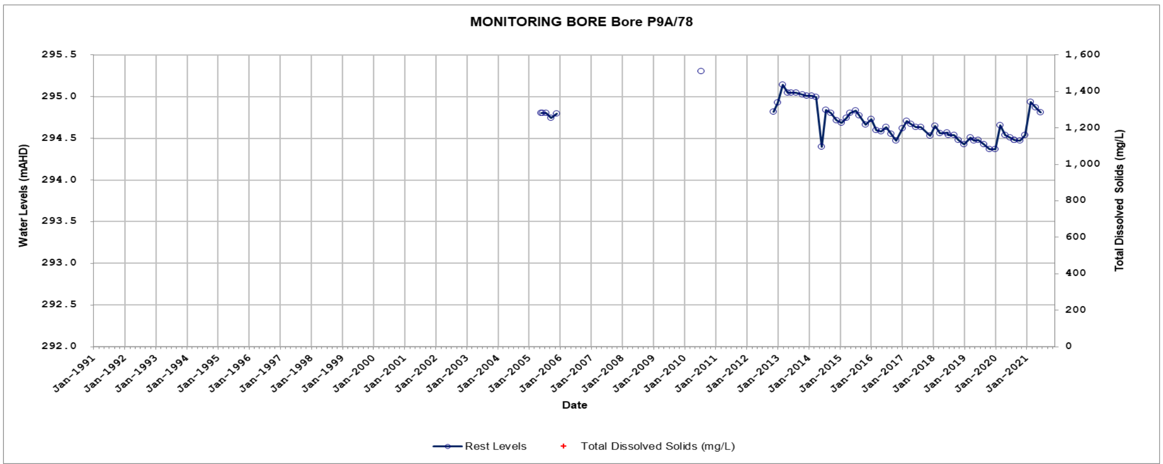

MONITORING BORE Bore P8/77
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

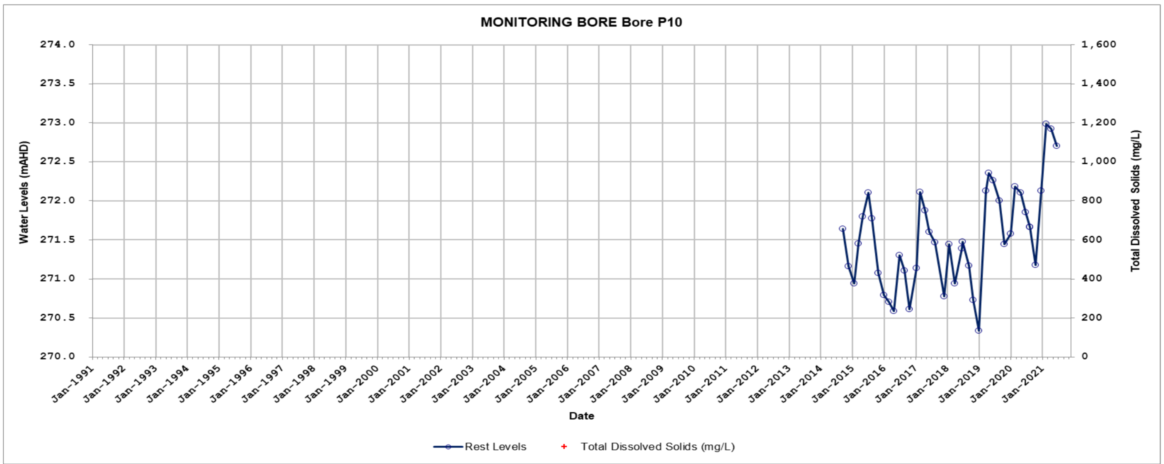

MONITORING BORE Bore P7/78
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

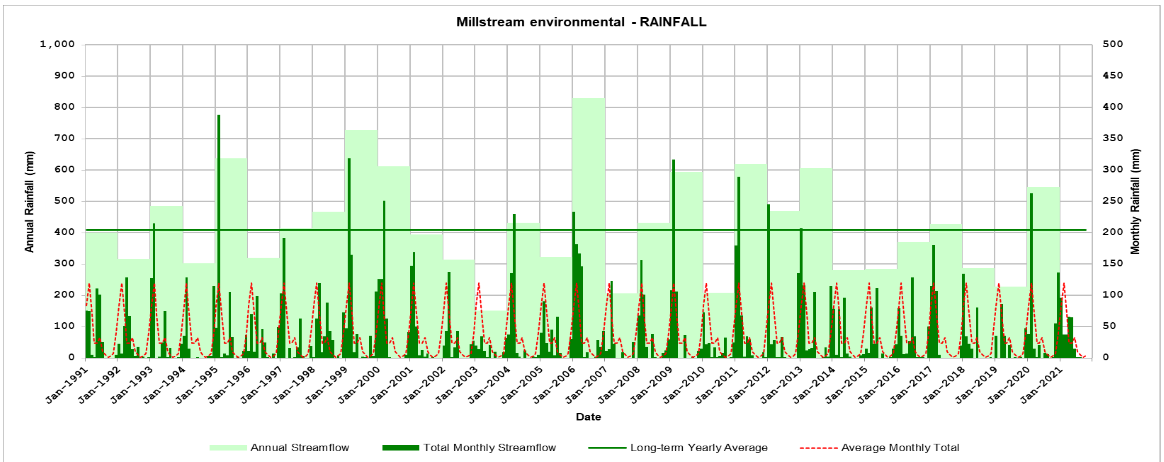

MONITORING BORE Bore 8/04
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

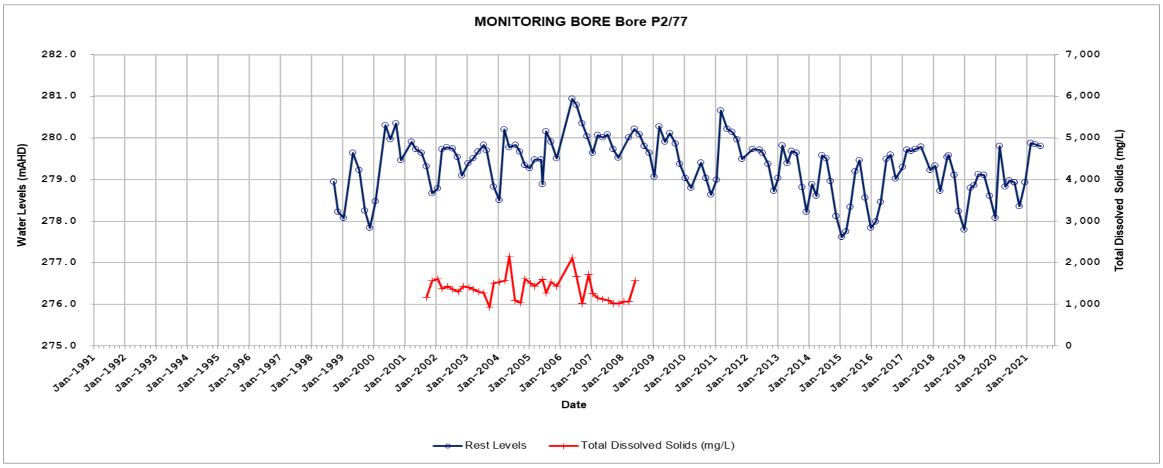

Millstream environmental - RAINFALL
Annual Rainfall (mm)
Monthly Rainfall (mm)
Date
Annual Streamflow
Total Monthly Streamflow
Long-term Yearly Average
Average Monthly Total

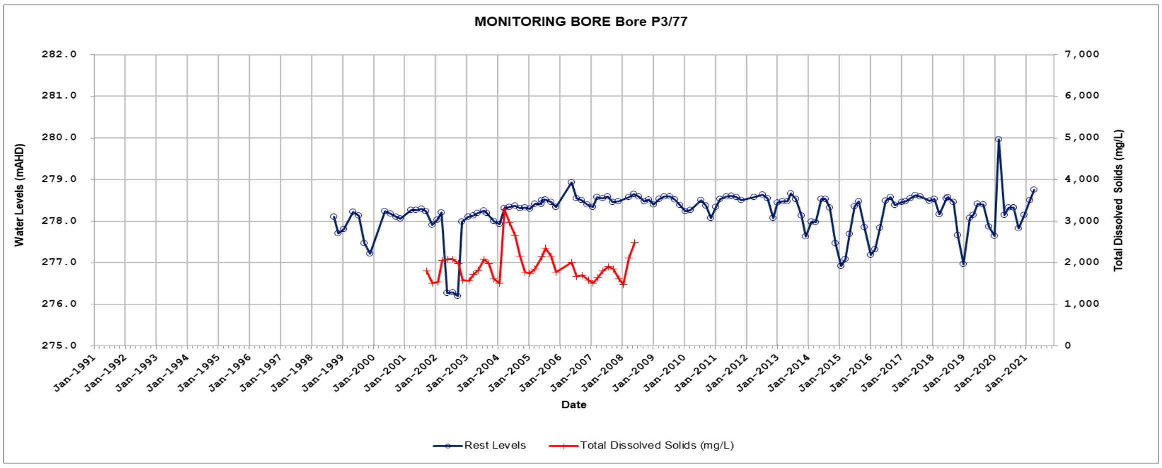

MONITORING BORE Bore P7/77
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

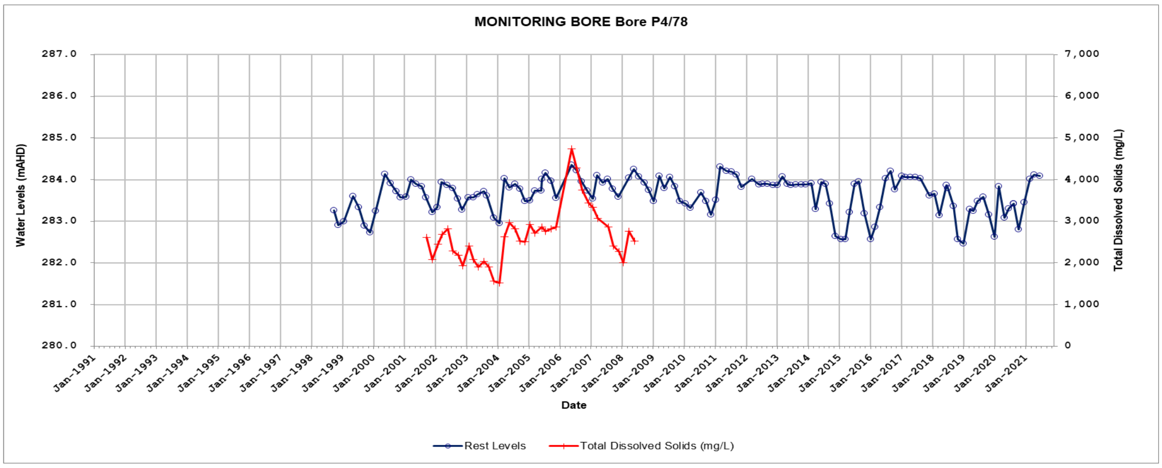

MONITORING BORE Bore P9A/78
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

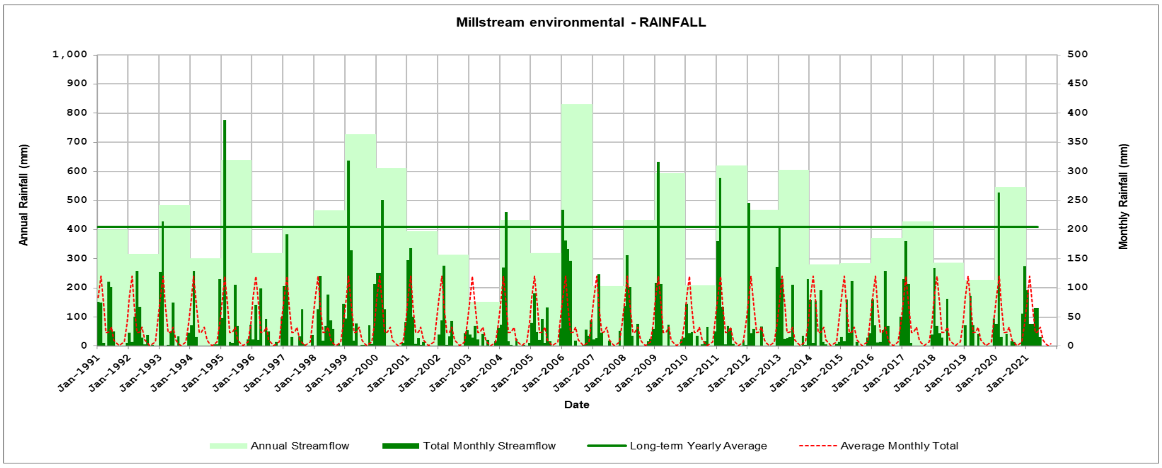

MONITORING BORE Bore P10
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

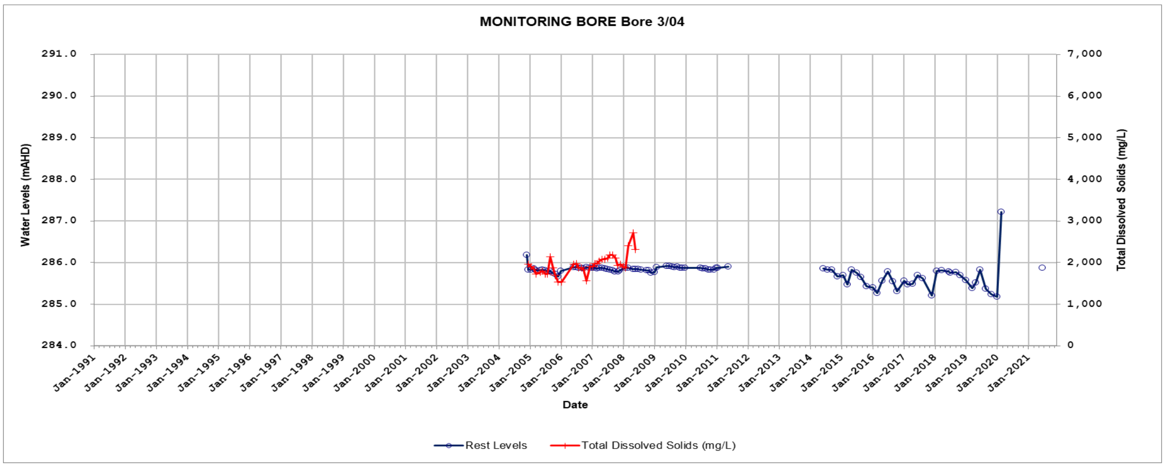

Millstream environmental - RAINFALL
Annual Rainfall (mm)
Monthly Rainfall (mm)
Date
Annual Streamflow
Total Monthly Streamflow
Long-term Yearly Average
Average Monthly Total

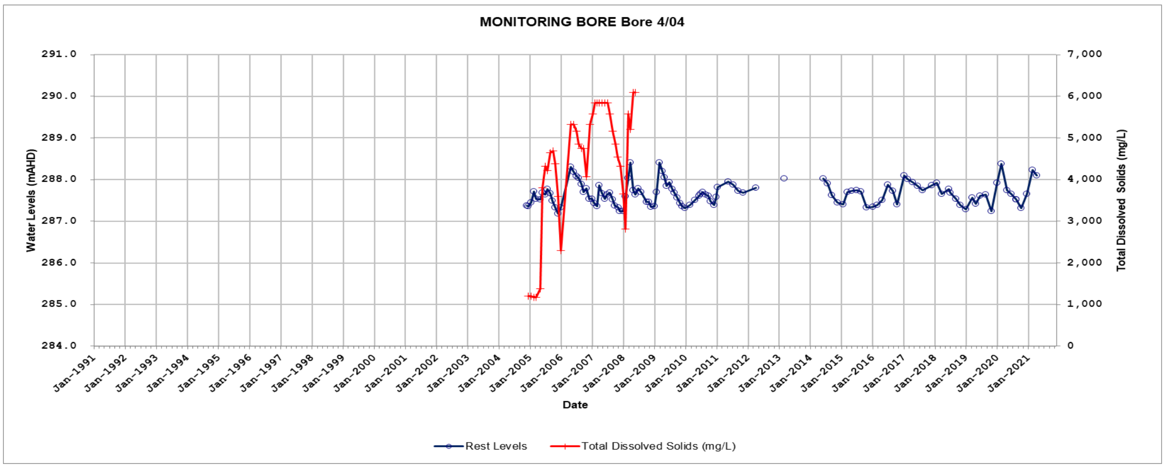

MONITORING BORE Bore P2/77
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

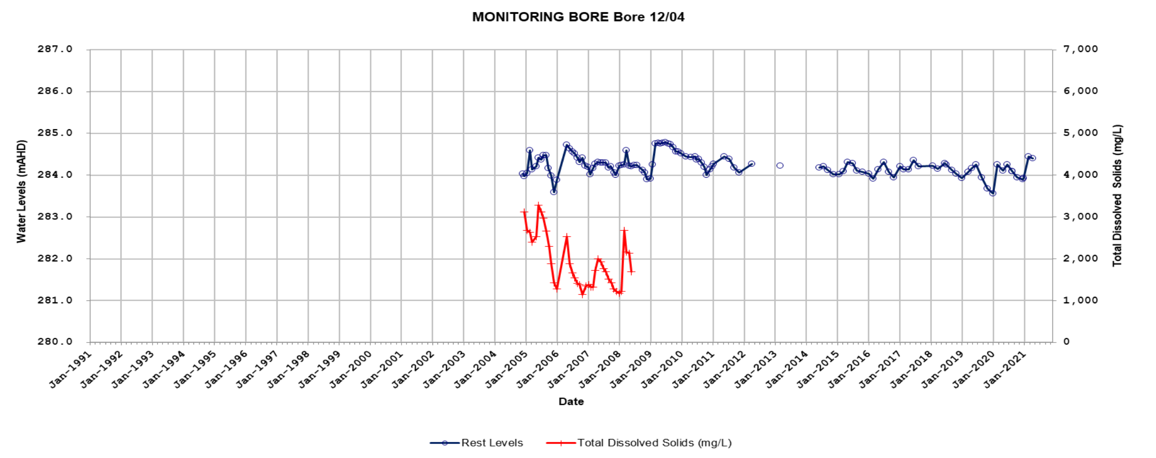

MONITORING BORE Bore P3/77
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)

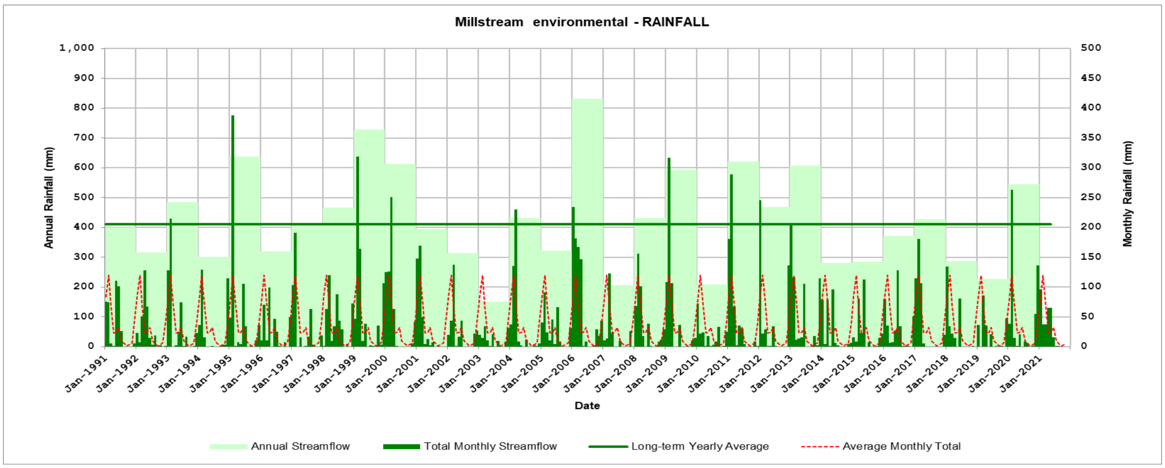

MONITORING BORE Bore P4/78
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)


Millstream environmental - RAINFALL
Annual Rainfall (mm)
Monthly Rainfall (mm)
Date
Annual Streamflow
Total Monthly Streamflow
Long-term Yearly Average
Average Monthly Total


MONITORING BORE Bore 3/04
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)


MONITORING BORE Bore 4/04
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)


MONITORING BORE Bore 12/04
Water Levels (mAHD)
Total Dissolved Solids (mg/L)
Date
Rest Levels
Total Dissolved Solids (mg/L)


Millstream environmental - RAINFALL
Annual Rainfall (mm)
Monthly Rainfall (mm)
Date
Annual Streamflow
Total Monthly Streamflow
Long-term Yearly Average
Average Monthly Total

APPENDIX F
Water Quality

Parameters	Unit	2011 NHMRC Guidelines		Millstream Bore 1 min - max med	Millstream Bore 2 min - max med	Millstream Bore 3 min - max med	Millstream Bore 4 min - max med	Millstream Bore 5 min - max med	Millstream Bore 6 min - max med	Harding Dam min - max med	Supernatant Discharge min - max med
		Aesthetic	Health								
Alkalinity as CaCO3	mg/L	-	-	290 - 330 320	280 - 320 310	290 - 310 300	290 - 300 290	280 - 350 330	290 - 300 290	100 - 260 180	140 - 260 210
Aluminium unfiltered	mg/L	0.2	-	<0.008 - <0.008 <0.008	<0.008 - <0.008 <0.008	<0.008 - <0.008 <0.008	<0.008 - <0.008 <0.008	<0.008 - <0.008 <0.008	<0.008 - <0.008 <0.008	<0.008 - 0.11 0.014	0.04 - **0.31** 0.095
Calcium	mg/L	-	-	74 - 87 81	72 - 80 76	70 - 72 72	70 - 77 72	75 - 89 86	67 - 69 69	14 - 37 23	22 - 30 25
Chloride	mg/L	250	-	125 - 195 190	105 - 150 145	95 - 100 95	105 - 145 125	130 - 195 185	110 - 115 115	24 - 115 45	75 - 150 110
Colour - True	HU	15	-	<1 - 1 1	<1 - <1 <1	<1 - <1 <1	<1 - <1 <1	<1 - <1 <1	<1 - <1 <1	4 - **29** 7	4 - 14 8
Conductivity at 25 C	mS/m	-	-	97 - 154 123	95 - 147 106	91 - 99 95	92 - 125 100	102 - 141 123.5	96 - 107 100	31 - 82 49	57 - 108 89
Hardness as CaCO3	mg/L	200	-	**370 - 450** **420**	**360 - 410** **380**	**350 - 360** **360**	**350 - 390** **360**	**380 - 460** **440**	**340 - 350** **350**	89 - 200 150	160 - **260** 200
Iron unfiltered	mg/L	0.3	-	0.015 - 0.045 0.015	<0.003 - 0.05 0.008	0.004 - 0.025 0.015	0.01 - 0.07 0.015	0.01 - 0.05 0.025	0.004 - 0.04 0.02	0.01 - 0.16 0.025	0.006 - 0.035 0.01
Magnesium	mg/L	-	-	45 - 57 53	43 - 50 47	42 - 43 43	42 - 49 44	46 - 57 55	42 - 42 42	12 - 36 20	24 - 45 36
Manganese unfiltered	mg/L	0.1	0.5	<0.002 - <0.002 <0.002	<0.002 - <0.002 <0.002	<0.002 - 0.008 <0.002	<0.002 - <0.002 <0.002	<0.002 - 0.003 0.002	<0.002 - <0.002 <0.002	0.003 - **0.38** 0.012	0.012 - 0.075 0.03
Nitrite plus nitrate as N	mg/L	-	11.29	1.5 - 2 1.6	1.7 - 1.8 1.8	2.1 - 2.2 2.2	1.6 - 2.2 2	1.3 - 1.7 1.4	2.1 - 2.3 2.1	<0.05 - 0.35 <0.05	<0.05 - 0.15 0.078
pH measured in laboratory	no unit	6.5 - 8.5	-	7 - 7.17 7.13	7.11 - 7.22 7.21	7.06 - 7.23 7.15	7.09 - 7.41 7.2	7.21 - 7.56 7.53	7.2 - 7.61 7.55	7.62 - **8.82** **8.6**	7.64 - **8.75** 8.17
Potassium	mg/L	-	-	9.8 - 13 12	9.2 - 11 11	8.8 - 8.8 8.8	9 - 11 9.8	10 - 12 12	9 - 9.6 9.4	3.6 - 8.4 4.6	2.6 - 9.2 6
Silicon as SiO2	mg/L	80	-	55 - 60 60	60 - 60 60	60 - 60 60	55 - 60 60	55 - 60 60	55 - 60 60	9.5 - 17 12	1.9 - 13 8.8
Sodium	mg/L	180	-	68 - 110 100	60 - 81 75	55 - 56 55	60 - 81 67	72 - 105 100	61 - 64 63	23 - 81 40.5	56 - 115 105
Sulphate	mg/L	250	500	61 - 97 90	54 - 74 66	49 - 50 50	55 - 72 60	64 - 92 89	58 - 59 58	4 - 11 6.5	29 - 77 69
Salinity	mg/L	600	-	**610 - 907** **746**	600 - **871** **657**	579 - **621** 600	584 - **756** **626**	**636 - 840** **748**	**605 - 662** **626**	560 - 560 560	NM
ND: No Detection				NM: No Measurement			**Bold**, shaded values outside NHMRC guidelines				