Summary: Assessment of Ti Tree Aquifer Water Resource 2024

NORTHERN TERRITORY GOVERNMENT

Document title	Summary: Assessment of Ti Tree Aquifer Water Resource 2024
Contact details	Department of Lands, Planning and Environment Water Resources Division
Approved by	Executive Director Water Resources
Date approved	February 2025
TRM number	42-D24-26575

Version	Date	Author	Changes made
0.1	4 November 2024	Water Management	First draft
0.2	11 November 2024	Water Management	Review
0.3	19 December 2024	Water Assessment	Review
0.4	15 January 2025	Water Management	Draft for Director review
0.5	4 February 2025	Water Management	Revision based on ED WRD comments

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Acknowledgement of Country

The Northern Territory Government respectfully and proudly acknowledges the Northern Territory's Aboriginal people and their rich cultures. We pay respect to Elders past and present. We acknowledge Aboriginal peoples as the traditional owners and custodians of the lands and waters that we rely on for our livelihoods. We recognise the intrinsic connection of traditional owners to Country and value their ongoing contribution to managing the lands and waters. We support the need for genuine and lasting partnerships with traditional owners to better understand cultural connections, and we will work to establish lasting partnerships to manage water together, now and into the future.

Table of contents

List of figures

Executive summary

- This is a summary of the 2024 *Water Resources Assessment: Ti Tree Palaeovalley Aquifer* (Water Resources Technical Report T25/2024)[1], that has been prepared by the department as part of the five year review of the Ti Tree water allocation plan 2020–2030.
- This technical summary identifies the key findings of Water Resources Assessment Report (the Assessment) which have been used to assess if the scientific assumptions of the plan have changed, and if there are new or increased risks.
- The Assessment found:
  - **Climate and rainfall** characteristics of the resource are consistent with assumptions in the plan. The assessment identified that a combination of both rainfall levels and the rainfall patterns may be a better predictor of flow at Allungra Creek than rainfall levels alone.
  - **Geology and hydrogeology** of the system was generally confirmed, with new information from a 2021 Geoscience Australia study improving understanding of deep aquifers and the basement geology.
  - **Recharge** mechanisms are known to be complex. The assessment documents a refined understanding of the relationship between rainfall and recharge, however further work is recommended. Model recalibration (due 2026) will contribute to an improved understanding, as will the addition of two bores to the monitoring program in 2024.
  - **Water quality** trends have not been monitored over the review period. Risks around water quality were found to be moderate with current controls in place, however additional water quality monitoring is recommended.
  - **Groundwater modelling** shows consensus with measured water levels in the plan area, however there are notable deviations around the 'neck' of the basin and irrigated areas. Model recalibration is planned for 2026.
    - **Limits of change** were not directly assessed however modelling indicates drawdown from extraction is likely to occur in the central basin if full water entitlements are utilised, whilst rising water levels due to recharge occurring at the basin margins. Drawdown rates are predicted within natural conditions at the basin scale.
    - **The natural water balance** was updated with data from 1970 to 2024 and refined to include the low yield zone. Overall recharge estimates, which were important to determine the estimated sustainable yield, remain the same for the Northern groundwater management zone (GMZ) and increased slightly for the Southern GMZ.
  - **Groundwater dependent ecosystem (GDE) occurrence** was considered using updated vegetation mapping from satellite imagery and analysis of Actual Evapotranspiration. GDE outside of the groundwater protection area were identified at Woodforde River and Allungra Creek, however both are understood to be accessing perched water sources separate from the Ti Tree aquifer.

[1] https://territorystories.nt.gov.au/10070/986725

Introduction

The Ti Tree water allocation plan 2020–2030 (the plan) manages groundwater in the Ti Tree Palaeovalley Aquifer (the aquifer). The aquifer underlies an area of around 5,000 km^2 of low, sandy soil rises surrounded by higher elevation basement hills. The aquifer provides water for the communities of Ti Tree and Pmara Jutunta as well as for livestock and horticulture, whilst sustaining local ecosystems and numerous sites of high cultural importance.

The plan area covers the entirety of Ti Tree water control district which has a total area of about 14,000 km^2 and includes the Ti Tree basin and its surrounding catchments (Figure 1). The water control district lies approximately 200 km north of Alice Springs (Figure 1).

Under the *Water Act 1992*, reviews of water allocation plans are to be conducted at intervals of no longer than five years. The primary objectives of the midterm review are to determine:

- if the scientific assumptions on which a plan is based, have changed
- whether there is a new or increased risk to the water resource
- whether the plan is achieving its objectives.

A detailed technical report was prepared to support the plan review and future work in the area, *Water Resources Assessment: Ti Tree Palaeovalley Aquifer* (Water Resources Technical Report T25/2024), hence referred to as the Assessment.

The assessment provides up to date analysis of long term climatic and hydrological data sets for surface water and groundwater resources, as well as a wide range of environmental, geological, and hydrogeological data for the Ti Tree basin.

This technical summary identifies the key findings of the Assessment which have been used to assess if the scientific assumptions of the plan have changed, and if there are new or increased risks.

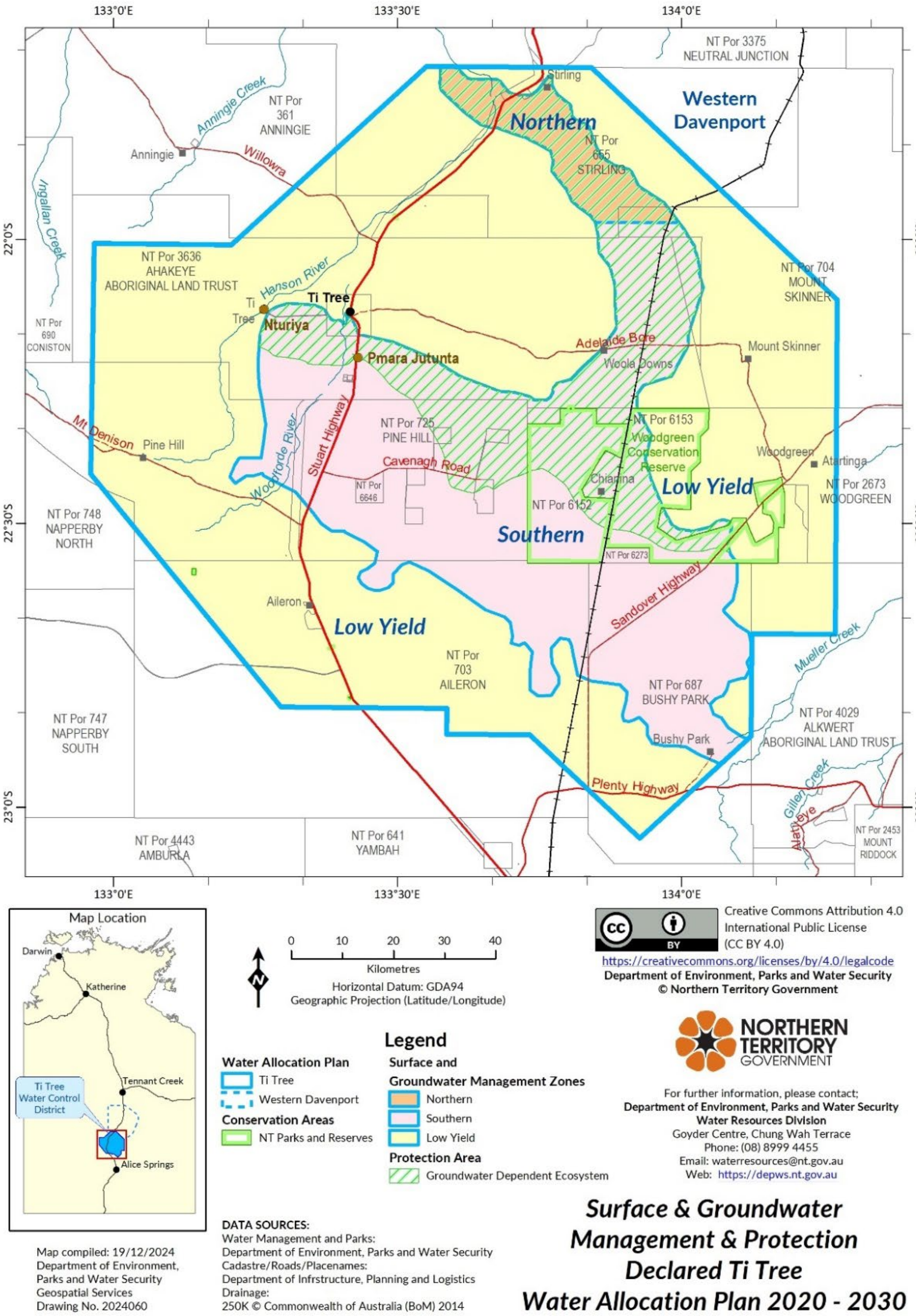

Figure 1: Map of Ti Tree water control district and showing water management zones and the groundwater dependent ecosystem protection area.

Scientific assumptions of the plan

This section summarises key scientific assumptions of the plan, and related findings of the Assessment.

Climate and rainfall

Climate and rainfall data available at the time of the plan identified that average annual rainfall is around 300 mm in the area. Updated analysis in the Assessment was consistent, identifying long term average annual rainfall from 1990 to 2024 of 300.6 mm.

In the short term, from 2019 to 2024 annual rainfall has been 375 mm, which is above the long term annual average. This higher than average rainfall has occurred despite a very low rainfall year in 2019 where just 43 mm of rain fell, which was atypical even for an Arid environment.

There are two surface water monitoring sites with continuous recorders on Allungra Creek, monitored since 2010 and the Woodforde River, monitored since 1974 (Figure 2). Flow is typically intermittent with periods of no flow occurring annually and inter-annually commonly with durations of two to three years during dry periods.

Monthly rainfalls of around 100 mm are significant for the plan area as this was understood to be a threshold for regional rivers flowing. For the period 2019 to 2024 there were five instances where monthly rainfall exceeded 100 mm, the highest, 300 mm occurring in December 2020.

In the Woodforde River substantial flows were observed in 2020 as well as 2023 and 2024. Below average flows were recorded in 2021 and 2022. No flows were observed in 2019 an unusually dry year.

No flow was observed in Allungra Creek in 2020. As a result, the Assessment found that rainfall levels combined with the rainfall patterns may be a better predictor of flow at Allungra Creek than rainfall levels alone.

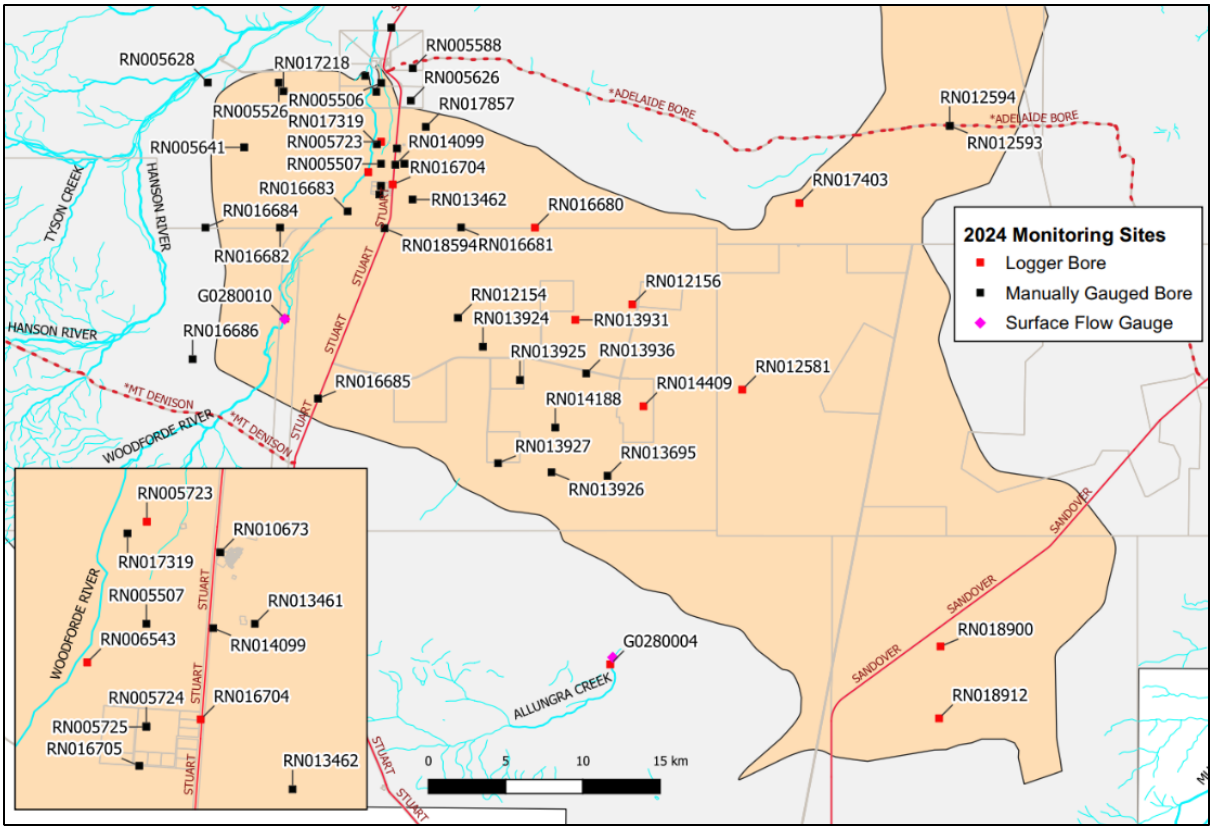

Figure 2 Map of monitoring sites across Ti Tree water control district showing surface water flow gauge locations on Allungra Creek and Woodforde River in pink

Geology

The Ti Tree aquifer is classified as a ‘paleovalley aquifer,’ an ancient valley which has filled with sediments over time. Many of these buried valleys contain active groundwater systems. The Assessment generally confirmed the geology and hydrogeology of the system, with new information from a 2021 Geoscience Australia study improving understanding of deep aquifers and the basement geology (Burton and Clarke, 2021).

The 2021 study identified potential for a deep trough in the center of the basin, extending to 500 m below surface, around 100 m deeper than previously thought. The study supported previous theories that the deep aquifer is separated from the shallow aquifer, managed under the plan, by a layer of fine grained sediments. Disruption to the separation of the shallow and deep aquifers may pose a risk of salinisation due to the deeper aquifer being more saline than the freshwater shallow aquifer. The Assessment considered risks to water quality as moderate, with current controls in place.

Recharge

Recharge is the process by which underground aquifers are replenished, and can occur through multiple mechanisms, broadly including direct rainfall where aquifers intersect the surface, river and creek flows, shallow groundwaters percolating slowly into deeper groundwaters, or a mix of all three, amongst others. These are further described below. The Ti Tree water resource is typical of the Arid Zone, with low annual rainfall and relatively high rates of evapotranspiration contributing to long periods of little to no groundwater recharge. Recharge events occur every seven to ten years, correlated to significant rainfall events.

The relationship between rainfall and aquifer recharge was understood to be complex and varied across the plan area. Mechanisms for recharge include mountain front recharge and seepage from floodouts. Allungra Creek floodout is understood to be an important recharge mechanism, allowing fresh water to enter the center of the basin. Every 10 to 20 years the perched aquifer underlying the Woodforde River is also understood to spill over and recharge the Ti Tree Palaeovalley Aquifer.

Significant recharge events sufficient to trigger a groundwater recharge response were thought to occur after at least 600-700 mm of rainfall in a season. A review of groundwater monitoring data dating from 1967 indicates that recharge will occur after an annual rainfall of around 500 mm.

The Assessment considers the risks around recharge to be high, and recommends further controls to mitigate this to a moderate risk in the future including:

- extending monitoring
- further refinement of the conceptual understanding of the resource
- improving understanding of groundwater flux.

Two additional bores were added to the monitoring program in June 2024 to improve understanding of potential mountain-front recharge, RN018900 and RN0189012.

Model recalibration is scheduled for 2026 as part of a project being conducted by the Department under the federally funded National Water Grid science program. It will improve the representation of the groundwater system including the ability to characterise recharge, through incorporation of additional studies and field data gained since development of the model in 2007.

Water quality

Groundwater quality in the plan area, both salinity and trace element concentrations, varies both spatially and with depth. Water quality for groundwater and surface water were assessed prior to 2019, with no recent data measurements. Data from previous water quality assessments have been analysed, however there is insufficient data across the monitoring bore network to assess water quality trends over time. Water quality results from surface water are also limited.

As discussed under Geology, risks to water quality were considered to be moderate with current controls in place. The Assessment recommended a groundwater survey for agrichemicals.

Natural water balance

The groundwater model was used to determine the natural water balance which is based on no groundwater pumping occurring in the basin i.e. under natural system behavior. The natural water balance applied in the plan considered only the southern and northern groundwater management zones (GMZ) (Figure 3). It was determined in the plan that the water balance for the low yield groundwater management zone has less relevance for water management purposes as it is generally not available for extractive use, except rural stock and domestic use.

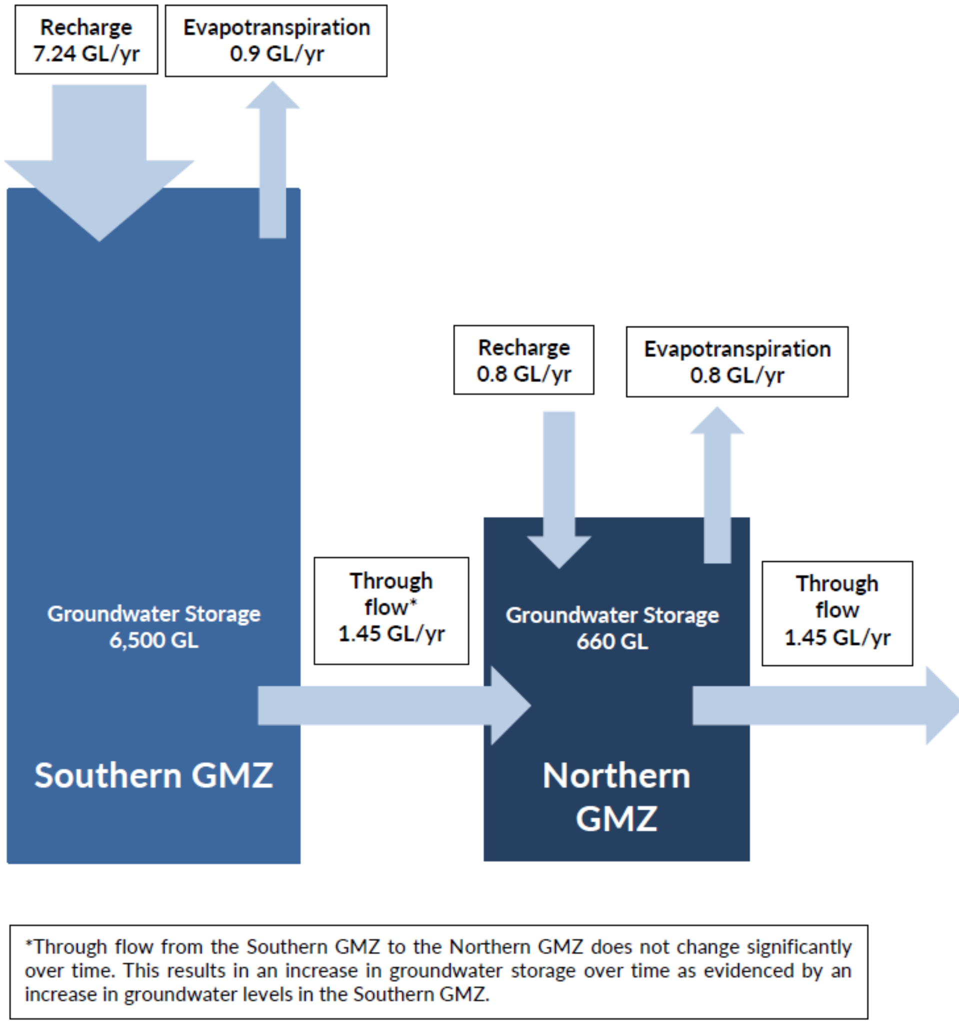

Figure 3: Natural water balance of the Ti Tree Aquifer system from the Ti Tree water allocation plan 2020-2030.

In the Assessment, the low yield GMZ has been included into the balance because there is evidence that groundwater from the low yield zone may be contributing to the aquifer within the basin (Figure 4). Updated data was integrated into the balance, which now indicates average annualised values over 54 years (1970 to 2024). The saturated thickness of the aquifer, as of 1 November 2023 when storage is predicted to be at its lowest for the year, was used to-estimate storage volume.

Overall, modelled values of the water balance are considered to represent acceptable results with moderate certainty over the long term.

The key parameter used in establishing the estimated sustainable yield of the plan was the recharge. Recharge estimates remain the same for the northern GMZ. In the southern GMZ, recharge has been assigned in more detail than in the previous water balance, accounting for both recharge from the low yield GMZ and other recharge sources. Overall, recharge estimates have increased for the southern GMZ by 0.1 GL per year compared with the plan.

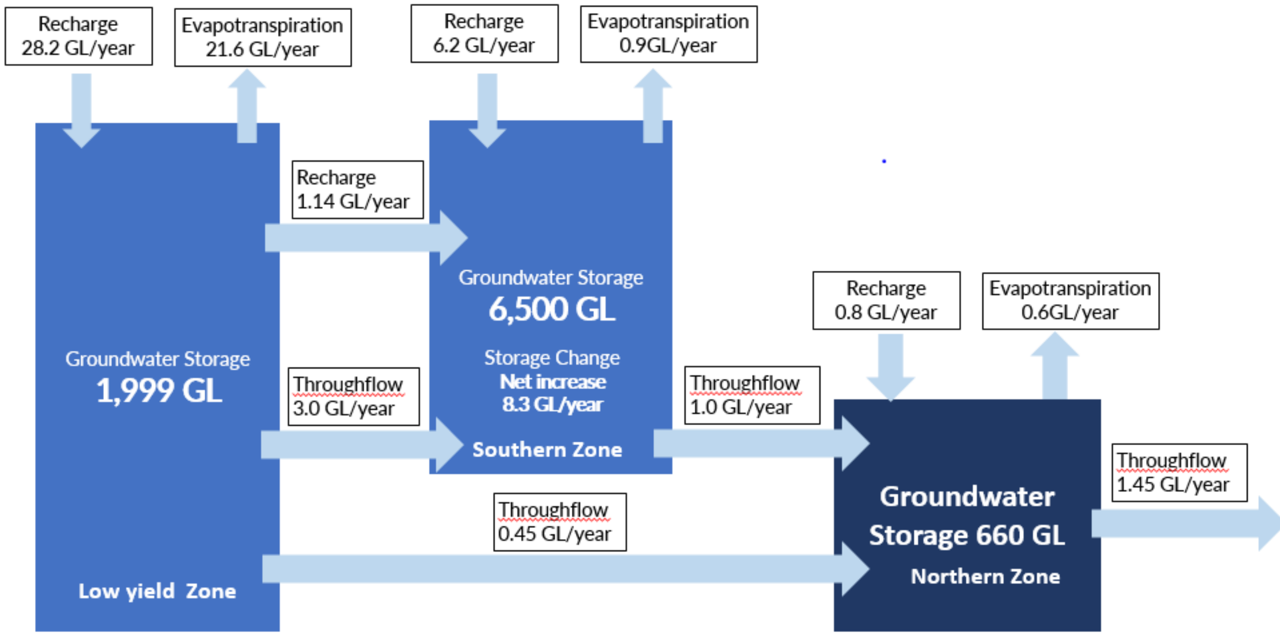

Figure 4: Natural water balance for the Ti Tree Aquifer from the Assessment.

Groundwater modelling

As part of the Assessment the groundwater model (Knapton, 2007) was run over the period 1970 to 2024, to assess the following scenarios (SC):

- SC0: Natural conditions.
- SC1: Actual usage - reported usage from licenced users and estimated usage from stock and domestic bores.
- SC2: Full entitlements - full entitlements and estimated usage from stock and domestic bores.

While there are locations where the modelled predictions do not match observed water level trends, notably in the ‘neck’ area and within the irrigated areas, there is consensus across the basin that measured and predicted water levels are rising around the periphery and falling within the center and north of the basin.

As discussed in Recharge, additional monitoring bores have been added to the monitoring regime to improve understanding of recharge mechanisms.

The Ti Tree model is scheduled for recalibration in 2026 and will incorporate additional studies and extensive new data including recently acquired high resolution LiDAR survey data also obtained through the National Water Grid science program.

Limits of change

Based on previous studies, the plan includes assumptions that GDE are likely to occur where depth to groundwater is 15 m or less (Cook and Eamus, 2018). The plan set a GDE protection area linked to this depth to groundwater. Further, limits to change in groundwater levels were set to ensure declines in groundwater level do not impact on GDE.

Drawdown predictions modelled under full extraction scenarios (SC0 minus SC2) for 50 years were predicted to drop by approximately:

- 2 to 3 m across the Central basin
- 8 to 12 m in the central horticultural areas
- 9 m under the Ti Tree Farms south of Pmara Jutunta
- less than 0.1 m within the northern zone ('neck').

The Assessment found that the average drawdown is comparable to the estimated natural recession of 0.1 to 0.2 m per year, which amounts to between 5.4 m and 10.8 m respectively over 54 years. The results indicate that overall drawdown from extraction of full water entitlements is likely to be balanced by recharge.

Occurrence of groundwater dependent ecosystems

The plan assumes that declining water levels will impact GDE, in particular vegetation. The plan set a GDE protection zone for areas with a depth to groundwater of less than 15 m based on studies of groundwater use by vegetation in Central Australia (Cook and Eamus, 2018).

Vegetation mapping to identify GDE using high resolution satellite imagery was conducted over the period 2015-2024. A high likelihood of GDE were identified in the northern GMZ, where the groundwater table is typically shallower than 10 meters below ground level (mBGL). The mapping found a lower probability of GDE at Stirling Swamp where water is shallow (0-5 mBGL). In this location, there are areas of bare soil and patches of seasonal salt-tolerant species, indicating that both salinity and depth to water affect the presence of GDE.

Areas with a high probability for presence of GDE were mapped throughout the basement hills, which do not overlie the Ti Tree aquifer. In these areas it is understood that surface runoff into localised fractures and rockholes may support the GDE which occur along the line of the hill outcrops.

Some areas with a lower likelihood of GDE were identified west of the Woodforde River, within the Ti Tree aquifer boundary, but outside of the GDE protection zone. These GDE are located within the perched aquifer that underlies the Woodforde River channel which was known to exist at the time of the plan.

Protection of cultural and environmental values

The plan recognised that there was likely to be a close association between Aboriginal cultural values and environmental values in the area. In the absence of specific Aboriginal cultural values research at the local scale, GDE and water levels have been used as a proxy in the original plan for Aboriginal cultural water requirements.

A collaborative approach is needed to improve understanding of the relationship between the environmental and cultural values. This will be a key component of the Aboriginal Water Science Project, which is discussed in the the midterm review of the Ti Tree water allocation plan 2020-2030[2].

[2] https://nt.gov.au/environment/water/management-security/water-control-districts/ti-tree/ti-tree-water-allocation-plan-multi

Risks

This section summarises risks identified in the plan as they relate to scientific findings of the assessment. An updated risk assessment for the plan is documented in the midterm review of the Ti Tree water allocation plan 2020-2030.

Climate variability and change

The Ti Tree basin is characterised by highly variable climate, which drives the biggest risk to the plan area being a lack of rainfall/drought which affects recharge and thus groundwater levels. Climate change may increase the frequencies of these events occurring. The estimated sustainable yield has been determined based on over 100 years of historic climatic data which incorporates both periods of drought and high rainfall years. However, the possible effect of future climate change and trends on the long term availability of water in the basin has not been specifically assessed. The Assessment did not identify significant change to this risk since development of the plan.

Proposed development and land use

The aquifer provides water for the communities of Ti Tree and Pmara Jutunta, for pastoral activities and horticulture. The region's horticultural potential has resulted in investment in water based research and water resource management activities, particularly since the creation of horticulture blocks in the 2000's. Development and changes to land use was identified as a risk in the plan, the Assessment did not identify significant change to this risk since development of the plan.

Distribution of groundwater dependent ecosystems

Uncertainty about the location and extent of GDE was identified as a risk in the plan. A GDE protection area, and limits of change were established in the plan for areas where depth to water is less than 15 m.

Vegetation mapping using high resolution satellite imagery identified high probability GDE areas in the northern GMZ, and significant GDE areas in the surrounding hilly country. A band of GDE were mapped along the Woodforde River (Figure 4). Data indicates that these GDE are likely to be accessing the perched aquifer underneath the Woodforde River channel rather than the deeper Ti Tree basin aquifer, which mitigates risk of groundwater drawdown in the basin to the GDE. The Assessment has recommended further investigation into the perched system and deeper aquifer in this area to improve understanding, however risk was assessed to be low.

Groundwater assessment

Although the Ti Tree aquifer is a well studied palaeovalley aquifer, the underpinning science is limited by site accessibility and remoteness, and the distribution of monitoring sites across the aquifer. The Assessment identified that expanding the monitoring network in key locations could be a solution to address knowledge gaps of the Ti Tree basin and the connectivity with the surrounding hilly country. Further research is planned within the plan area which is discussed in the midterm review of the Ti Tree water allocation plan 2020-2030.

Groundwater modelling

Modelling of the Ti Tree aquifer has been used to estimate the volume of groundwater in storage, recharge and to predict how the aquifer would respond to extraction over time. Modelled predictions of water levels are relatively close to field observations in some locations, and in other areas the predictions diverge from field observations. The model will undergo a recalibration in 2026 to improve the aquifer characterisation of storage, recharge, discharge and groundwater flux. The updated model will incorporate more accurate LiDAR ground survey data, which will improve predictions of groundwater levels. More information on the recalibration can be found in the midterm review of the Ti Tree water allocation plan 2020-2030.

References

Burton, C. & Clarke, J. (2021). Exploring for the Future—Architecture of the deep Ti Tree Basin: Report 1. Northern Territory. Record 2021/11. Geoscience Australia, Canberra. http://dx.doi.org/10.11636/Record.2021.011

Cook, P.G. and Eamus, D. (2018) The potential for groundwater use by vegetation in the Australian Arid Zone (Report 33/2018). Northern Territory Government, Darwin, Australia. https://hdl.handle.net/10070/774780

Knapton, A. (2007). Development of groundwater model for the Ti Tree Basin (Report 18). Department of Natural Resources, Environment and the Arts. Territory Stories - Territory Stories (nt.gov.au)

Northern Territory Government (2024a). *Midterm Review: Ti Tree Water Allocation Plan (2020-2030)* Department of Lands, Planning and Environment, Northern Territory Government, Darwin, Australia. https://nt.gov.au/environment/water/management-security/water-control-districts/ti-tree/ti-tree-water-allocation-plan-multi

Northern Territory Government (2024b). *Water Resource Assessment: Ti Tree Palaeovalley Aquifer*. TR25/2024. Department of Lands, Planning and Environment, Northern Territory Government, Darwin, Australia. https://territorystories.nt.gov.au/10070/986725

Acronyms

Acronyms	Full form
GDE	groundwater dependent ecosystems
GMZ	groundwater management zones
km	kilometre
km^2	kilometre squared
m	metre
mBGL	metres below ground level
ML	megalitre (one million litres)
mm	millimetre

Dictionary

Terminology	Definition
actual evapotranspiration	the actual (measured) evaporative loss of water from a hydrologic system via evaporation or transpiration by plants
aquifer	see Water Act 1992
Arid Zone	a water resource as described in Classification of Top End and Arid Zone for Northern Territory Water Resources, Technical Report 55/2020
beneficial uses	see *Water Act 1992*, section 4(1)
bore	see *Water Act 1992*, section 4(1)
department	the department with responsibility for administering the *Water Act 1992* according to the Northern Territory of Australia Administration Arrangements Order
estimated sustainable yield (for the purposes of a plan)	the amount of water that can be allocated from the water resource to support declared beneficial uses that is acceptable. In determining the estimated sustainable yield, the following matters have been considered: • available data concerning inflows, recharge, outflows, evapotranspiration, and existing storage, in order to reasonably estimate the water available for consumptive use; • furthering the purposes of the Act stated in the Long Title, relevantly the 'allocation, use, control, protection, management and administration of water resources' by sustaining long term development of water resources and ensuring environmental integrity; • the objective of the statutory scheme to protect environmental water quality; • the Territory's commitment to the Intergovernmental Agreement on a National Water Initiative 2014, which defines 'environmentally sustainable level of extraction' to mean 'the level of water extraction from a particular system which, if exceeded would compromise key environmental assets, or ecosystem functions and the productive base of the resource'; and • 'environment' as defined in the Act includes the physical, biological, economic, cultural and social aspects of humans, and hence that an estimate sustainable yield that maintains environmental integrity therefore involves consideration of these aspects
groundwater	see *Water Act 1992*, section 4(1)
groundwater dependent ecosystem, GDE	an ecosystem that requires access to groundwater to meet all or some of their water requirements
LiDAR, Light Detection and Ranging	technology used to create high resolution models of ground elevation with a vertical accuracy of 10 centimeters
natural water balance	the natural water balance describes the inflows and outflows of water in a given area, and the resulting change in water storage over time. The natural water balance can be expressed using a simple flux equation: Inflow = outflow +/- change in storage The water balance is used to assess water availability in a given area and to plan the sustainable use of water resources
plan	Ti Tree water allocation plan 2020-2030

recharge	a hydrologic process whereby water moves from the earth's surface to groundwater. The recharge value represents the amount of water that goes into the groundwater system and may be expressed in units of depth/time, e.g. mm/year or volume/time, e.g. ML per year
surface water	see *Water Act 1992*, section 43
water control district	the Ti Tree water control district declared in Gazette G42 on 21 October 2009 section 22 of the *Water Act 1992*, also referred to as the district