Groundwater Dependent Ecosystem Assessment

Mahalo North CSG Development – Stage 2 GDE Assessment

Final A_October 2025

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Project No. 2024_19

Project Manager: David Stanton

Client: Epic Environmental

Purpose: Groundwater Dependent Ecosystem (GDE) risk assessment for the Mahalo North CSG development

Report	Revision	Date Issued	Issued By.	Purpose
Groundwater Dependent Ecosystem Assessment – Mahalo North CSG Development_ Stage 2, 2025	REV 1	20 October 2025	David Stanton	First draft report
	REV 2	23 October 2025	David Stanton	Final report following minor revisions

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Yours Sincerely,

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Glossary

Alluvial aquifer	An aquifer comprising unconsolidated sediments deposited by flowing water usually occurring beneath or adjacent to the channel of a river.
Aquifer	A geological formation or structure that stores or transmits water to wells or springs. Aquifers typically supply economic volumes of groundwater
Aquatic GDE	Vegetation supported by surface expression of groundwater (e.g., spring fed watercourses and associated fringing vegetation).
Base flow	Streamflow derived from groundwater seepage into a stream.
Capillary fringe	The unsaturated zone above the water table containing water in direct contact with the water table though at pressures that are less than atmospheric. Water is usually held by soil pores against gravity by capillary tension.
Confined aquifer	A layer of soil or rock below the land surface that is saturated with water with impermeable material above and below providing confining layers with the water in the aquifer under pressure.
Evapotranspiration	The movement of water from the landscape to the atmosphere including the sum of evaporation from the lands surface and transpiration from vegetation through stomata
Facultative phreatophyte	A plant that occasionally or seasonally utilises groundwater to maintain high transpiration rates, usually when other water sources aren't available.
Fractured rock aquifer	An aquifer in which water flows through and is stored in fractures in the rock caused by folding and faulting.
Fluvial	Relating to processes produced by or found in rivers
Groundwater	Those areas in the sub-surface where all soil or rock interstitial porosity is saturated with water. Includes the saturated zone and the capillary fringe.
Groundwater dependent ecosystems (GDE)	An ecosystem that depends, either wholly or partially, on groundwater to meet their moisture requirements to maintain ecological processes.
Infiltration	Passage of water into the soil by forces of gravity and capillarity, dependent on the properties of the soil and moisture content.
Leaf water potential (LWP)	The total potential for water in a leaf, consisting of the balance between osmotic potential (exerted from solutes), turgor pressure (hydrostatic pressure) and matric potential (the pressure exerted by the walls of capillaries and colloids in the cell wall).
Leaf area index (LAI)	The ratio of total one-sided area of leaves on a plant divided by the area of the canopy when projected vertically on to the ground.
Obligate phreatophyte	A plant that is completed dependent on access to groundwater for survival
Percolation	The downward movement of water through the soil due to gravity and hydraulic forces.
Permeability	A materials ability to allow a substance to pass through it, such as the ability of soil or rocks to conduct water under the influence of gravity and hydraulic forces.
Permanent wilting point	The water content of the soil at which a plant can no longer extract water and leaves will wilt and die. Usually 1.5 Mpa (-217 psi). Generally applied to crops although Australian flora typically have much larger stress thresholds.
Phreatic zone	The zone of sub-surface saturation separated from the unsaturated zone in unconfined aquifers by the water table.
Soil water potential	A measure of the difference between the free energy state of soil water and that of pure water. Essentially a measure of the energy required to extract moisture from soil.
Stable isotope	An isotope that does not undergo radioactive decay.
Standard Wilting Point	The minimum LWP or corresponding soil moisture potential that can be tolerated before a plant wilts in response to negative water supply. This is accepted at -15 bars or -1.5 MPa (or -217.55 PSI).

Specific Yield	The ratio of the volume of water that a saturated rock or soil will yield by gravity to the total volume of the rock or soil.
Surface water	Movement of water above the earths' surface as runoff or capture in streams and closed depressions.
Transpiration	The process of water loss from leaves, through stomata, to the atmosphere.
Terrestrial GDE	Terrestrial vegetation supported by sub-surface expression of groundwater (i.e., tree has roots in the capillary fringe of groundwater table).
Unconfined aquifer	An aquifer whose upper surface is at atmospheric pressure, producing a water table, which can rise and fall in response to recharge by rainfall
Vadose zone	The unsaturated zone, above the water table in unconfined aquifers
Water Potential	The free energy potential of water as applied to soils, leaves plants and the atmosphere.
Wetting front	The boundary of soil wet by water from rainfall and dry soil as the water moves downward in the unsaturated zone.

Executive Summary

Comet Ridge Mahalo North Ltd (Comet Ridge) proposes to develop The Mahalo North Project (the Project), a greenfield CSG development located in the Bowen Basin, between Rolleston and Blackwater, in an area defined as Petroleum License Application (PLA) 1128. The Project aims to produce Coal Seam Gas (CSG) from the Bandanna Formation. Coal seam gas developments have the potential to alter natural groundwater regimes and impact groundwater quality. This report provides a second stage of field investigation that assesses the potential impacts of groundwater extraction on native vegetation in PLA1128, following an initial phase of field investigation in August 2024. Consistent with the initial investigation (EV1), the second stage of assessment (EV2) utilises multiple lines of evidence, including pre-dawn leaf water potentials, soil moisture potentials, and analysis of stable isotope trends.

The two stages of assessment are consistent in their conclusions. Within the assessment area, brigalow (including the Brigalow Threatened Ecological Community) draws moisture predominantly from the shallow regions of the soil profile down to depths of 2.4 mbgl, where extremely dry and hard clays arrest deeper root penetration. There is no evidence for groundwater utilisation by brigalow from either biophysical or isotopic investigations completed within this broader assessment.

Like brigalow, eucalyptus woodland habitats across PLA1128 comprise mostly shallow-rooted box species that rely on moisture from the shallow soil profile. Support for this conceptualisation comes from both biophysical and isotopic evidence, which is broadly consistent across the two sampling events. Some eucalypt species, such as Dawson gum, have a strong affinity with brigalow, suggesting that they similarly derive moisture from similar shallow regions of the soil profile.

Based on this assessment, terrestrial GDEs do not occur within PLA1128, confirming that the impact of CSG development on groundwater-dependent assets will be negligible.

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Glossary

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Aquifer	A geological formation or structure that stores or transmits water to wells or springs. Aquifers typically supply economic volumes of groundwater
Aquatic GDE	Ecosystem supported by surface expression of groundwater (e.g. spring fed watercourses and associated fringing vegetation).
Base flow	Streamflow derived from groundwater seepage into a stream.
Capillary fringe	The unsaturated zone above the water table containing water in direct contact with the water table though at pressures that are less than atmospheric. Water is usually held by soil pores against gravity by capillary tension.
Confined aquifer	A layer of soil or rock below the land surface that is saturated with water with impermeable material above and below providing confining layers with the water in the aquifer under pressure.
Edaphic	Relating to properties of soil or substrate including its physical and chemical properties and controls those factors impose on living organisms.
Evapotranspiration	The movement of water from the landscape to the atmosphere including the sum of evaporation from the lands surface and transpiration from vegetation through stomata
Evaporative enrichment (of stable isotopes).	In a surface water body subject to evaporation, the d2H/d18O values of a water sample collected after a period of strong evaporation will be higher (more enriched in the heavier isotope) than the values obtained from water collected during an earlier sampling event. This reflects the progressive evaporation of water and loss of the lighter isotope under local conditions (assuming that there is not additional water inflow).
Facultative phreatophyte	A plant that occasionally or seasonally utilises groundwater to maintain high transpiration rates, usually when other water sources aren't available.
Fractured rock aquifer	An aquifer in which water flows through and is stored in fractures in the rock caused by folding and faulting.
Fluvial	Relating to processes produced by or found in rivers
Groundwater	Those areas in the sub-surface where all soil or rock interstitial porosity is saturated with water. Includes the saturated zone and the capillary fringe.
Water table	The upper surface of the saturated zone in the ground, where all the pore space is filled with water.
Groundwater dependent ecosystems (GDE)	Natural ecosystems which require access to groundwater on a permanent or intermittent basis to meet all or some of their water requirements so as to maintain their communities of plants and animals, ecological processes and ecosystem services (Richardson et al. 2011)

Infiltration	Passage of water into the soil by forces of gravity and capillarity, dependent on the properties of the soil and moisture content.
Leaf water potential (LWP)	The total potential for water in a leaf, consisting of the balance between osmotic potential (exerted from solutes), turgor pressure (hydrostatic pressure) and matric potential (the pressure exerted by the walls of capillaries and colloids in the cell wall).
Leaf area index (LAI)	The ratio of total one-sided area of leaves on a plant divided by the area of the canopy when projected vertically on to the ground.
Local Meteoric Water Line (LMWL)	Describes the relationship between hydrogen and oxygen isotope (Oxygen-18 and Deuterium) ratios in local natural meteoric waters. LMWL is usually developed from precipitation data collected from either a single location or a set of locations within a "localised" area of interest (USGS, 2018) and results are reported as the amount-weighted average d2H/d18O composition of water in rainfall. LMWL's define a constant relationship between d2H/d18O in local rainfall, and deviations from this relationship are imparted by stable isotope fractionation causally linked to evaporative processes (evaporative enrichment). Further information can be obtained from USGS (2004) and Crosbie et al (2012).
Obligate phreatophyte	A plant that is completely dependent on access to groundwater for survival
Osmotic potential	The lowering of free energy of water in a system due to the presence of solute particles.
Percolation	The downward movement of water through the soil due to gravity and hydraulic forces.
Perched groundwater system	A groundwater system or aquifer that sits above the regional aquifer due to a capture of infiltrating moisture on a discontinuous aquitard.
Permeability	A materials ability to allow a substance to pass through it, such as the ability of soil or rocks to conduct water under the influence of gravity and hydraulic forces.
Permanent wilting point	The water content of the soil at which a plant can no longer extract water and leaves will wilt and die. Usually -1.5 Mpa (-217 psi). Generally applied to crops although Australian flora typically have much larger stress thresholds.
Phreatic zone	The zone of sub-surface saturation separated from the unsaturated zone in unconfined aquifers by the water table.
Phreatophyte	Plants whose roots extend downward to the water table to obtain groundwater or water within the capillary fringe
Piston flow	The movement of a water front through the soil uniformly downwards to the aquifer, with the same velocity, negligible dispersion, pushing older water deeper into the soil profile.
Preferential flow	Movement of surface water rapidly from surface to aquifer along preferential flow paths, bypassing older moisture in the upper soil profile.
Stable isotope	A stable isotope is an isotope that does not undergo radioactive decay. Oxygen has three different isotopes: The ^{16}O is the most

	common stable isotope of oxygen and ^{18}O is present in the atmosphere in amounts that are measurable. The masses of ^{16}O and ^{18}O are different enough that these isotopes are separated (or fractionated) by the process of evaporation leading to enrichment of the heavier (^{18}O) isotope. Hydrogen has two naturally occurring stable isotopes being ^{1}H (protium) and ^{2}H (deuterium) which also fractionate during evaporation, although the higher energy state of hydrogen means that the ratio between ^{1}H and ^{2}H is much more sensitive to fractionation. Further information can be obtained from USGS (2004) and Singer (2014).
Standard Wilting Point	The minimum LWP or corresponding soil moisture potential that can be tolerated before a crop plant wilts in response to negative water supply. This is accepted at -15 bars or -1.5 MPa (or -217.55 PSI)
Specific Yield	The ratio of the volume of water that a saturated rock or soil will yield by gravity to the total volume of the rock or soil.
Surface water	Movement of water above the earths' surface as runoff or in streams
Transpiration	The process of water loss from leaves, through stomata, to the atmosphere.
Terrestrial GDE	Terrestrial vegetation supported by sub-surface expression of groundwater (i.e. tree has roots in the capillary fringe of groundwater table).
Turgor Pressure	Turgor pressure is the force exerted by stored water in a leaf against a cell wall.
Unconfined aquifer	An aquifer whose upper surface is at atmospheric pressure, producing a water table, which can rise and fall in response to recharge by rainfall
Vadose zone	The unsaturated zone, above the water table in unconfined aquifers
Water Potential	The free energy potential of water as applied to soils, leaves plants and the atmosphere.
Wetting front	The boundary of soil wet by water from rainfall and dry soil as the water moves downward in the unsaturated zone.

1.0 Introduction

Comet Ridge Mahalo North Ltd (Comet Ridge) proposes to develop The Mahalo North Project (the Project), a greenfield CSG development located in the Bowen Basin, between Rolleston and Blackwater, in an area defined as Petroleum License Application (PLA) 1128 (**Figure 1**). The Project aims to produce Coal Seam Gas (CSG) from the Bandanna Formation. This requires reducing reservoir pressure to facilitate the desorption of methane gas from coal, which is achieved by pumping groundwater from the source formation via constructed wells.

CSG developments have the potential to alter natural groundwater regimes and impact groundwater quality (Independent Expert Scientific Committee (IESC), 2018). Therefore, an assessment of the Project's potential impacts on ecosystems reliant on groundwater resources is required, captured under the general term of groundwater-dependent ecosystems (GDEs). GDEs are currently mapped within PLA 1128 (GDE Atlas, BOM 2024), necessitating a requirement for field inspection to confirm the presence and eco-hydrological function of GDEs, which includes:

1. Terrestrial GDEs rely on groundwater's sub-surface expression (into the tree-rooting zone).
2. Aquatic GDEs are GDEs dependent on the groundwater surface expression (springs and baseflow).

Figure 2 shows mapped terrestrial and aquatic GDEs. Mapping of Aquatic GDEs represents discontinuous slivers on small-order drainage lines on the southern boundary of PLA 1128. Terrestrial GDEs occupy much broader tracts of native vegetation, often on elevated landscape portions and removed from watercourses.

2.0 Background and Objectives

A request for information (RFI) issued to the proponent by the Australian Government Department of Climate Change, Energy, the Environment and Water (DCCEEW) identified several areas where additional information is required, before an assessment of The Projects impacts can be made, allowing a decision on Project approval. The RFI included the following:

1. Conduct an investigation to determine whether any linkage between Brigalow (*Acacia harpophylla)* TEC and groundwater exists. This investigation must be done using validated, ground-truthed methods such as Doody et al. (2019). Discuss the findings of these investigations within the PD and provide supporting evidence to inform whether these linkages exist and, if so,to what extent (2.1.7).
2. An assessment of the impacts of the proposed action on Brigalow TEC with respect to changes to surface hydrology and potential decline in groundwater availability and quality and whether this may reduce the condition of the community to the extent in which it would not meet the threshold to be classed as Brigalow TEC (2.3.8).
3. Provide a discussion with supporting evidence of the occurrence of terrestrial, aquatic and subterranean GDEs within, adjacent to and downstream of the

proposed action area. Groundwater dependency should be ground-truthed using a validated method, such as Doody et al. (2019) (3.3.4).

Based on this RFI, Watermark Eco conducted a field investigation of potential GDEs within the Mahalo tenements in August 2024, accompanied by the preparation of a GDE risk assessment (Watermark Ecohydrology, 2024). The field investigations completed in PLA1128 in August 2024, being the Event 1 (EV1) assessment concluded:

1. Within the assessment area, brigalow (including the Brigalow Threatened Ecological Community) draws moisture predominantly from the shallow regions of the soil profile down to depths of 2.4 mbgl. There is no evidence from either biophysical or isotopic investigations that indicates groundwater contributes significantly to the moisture sources supporting brigalow habitats within the Mahalo North Project Area.
2. Like brigalow, eucalyptus woodland habitats across PLA1128 comprise mostly shallow-rooted box species that rely on moisture from the shallow soil profile. Support for this conclusion comes from biophysical and isotopic evidence.

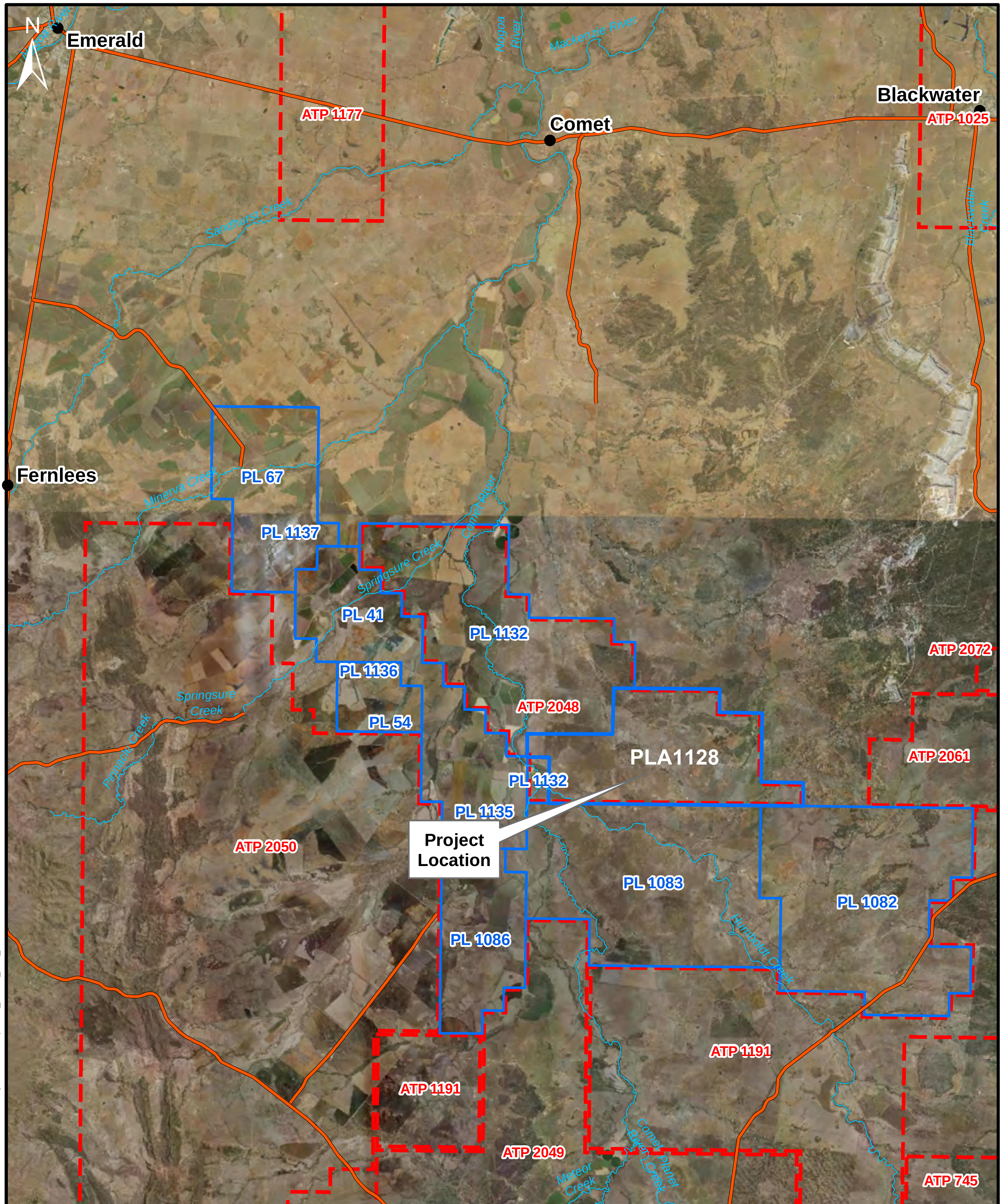
A subsequent GDE assessment was requested by DCCEEW, under recommendations from the IESC. The assessment scope was to complete an additional GDE assessment under climatic and seasonal conditions like those of the initial assessment, ensuring that vegetation moisture sources remain consistent over time. The objectives of the subsequent (EV2) assessment are consistent with those of the first, being to:

1. Complete field inspection of mapped Terrestrial GDE areas:
2. Undertake biophysical assessments to characterize the physical interactions of potentially groundwater-dependent trees with their edaphic controls.
3. Provide a subsequent phase of stable isotope investigations to identify the source, or sources of moisture utilised by areas currently mapped as GDEs.

Consistent with the original RFI, the EV2 study will focus on areas of the Brigalow TEC. However, the study will provide broader information on other habitats within and adjacent to PLA 1128 to allow an adequate assessment of the Project's risks to GDE function.

3.0 Survey Timing, Rainfall and Climate.

The field survey for the Stage 2 GDE assessment occurred over five field days between the 4th and 8th of August 2025, seasonally consistent with the initial assessment completed between the 26th and 30th of August 2024. Figure 3 shows the pre-survey rainfall reported in Arcturus Downs (BOM recording station 035002), approximately 20km west of PLA 1128, for three months before the field assessment from May 2025. Significant rainfall occurred on the 16th and 23rd May, with 13 and 25 mm reported respectively, plus an additional 37 mm recorded between the 23rd and 27th July, the week prior to the field assessment. Outside these rainfall events, the three months leading up to the assessment were dry. Analysis of SILO rainfall data (SILO 2025) expressed as Cumulative Rainfall Departure (CRD) (Weber & Stuart, 2004) is shown in Figure 4, indicating that the initial field assessment followed a strong wetting trend that occurred between April 2022 and February 2023, periodically drying to September 2023, with a weaker wetting trend recorded from this point to the commencement of the EV1 field survey. A short-term reduction in rainfall volumes occurred from EV1 to December 2024. Rainfall volumes were again above average until May 2025, after which they moderated. The CRD data also shows significant droughts (troughs in the CRD curve) occurring between 2001 and 2007 (the Millennium drought) and between 2017 and June 2021. CRD is essential for assessing groundwater-related assets, as shallow groundwater tables will follow similar trends.



Scale 1:400,000@ A4 0 10,000 20,000 M

Coordinate System: GDA 2020 MGA Zone 55 A4

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Legend

- State_controlled_roads_s...
- Watercourse
- PLA 1128
- Petroleum_leases
- Exploration permits for petroleum

Figure 1. Comet Ridge Mahalo Project Location

Client: Epic Environmental

Project: Comet Ridge Mahalo Project.

WATER MARK ECO

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Mobile: 0447 822 119
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Drawn By DG Checked DS Date 4/12/2024

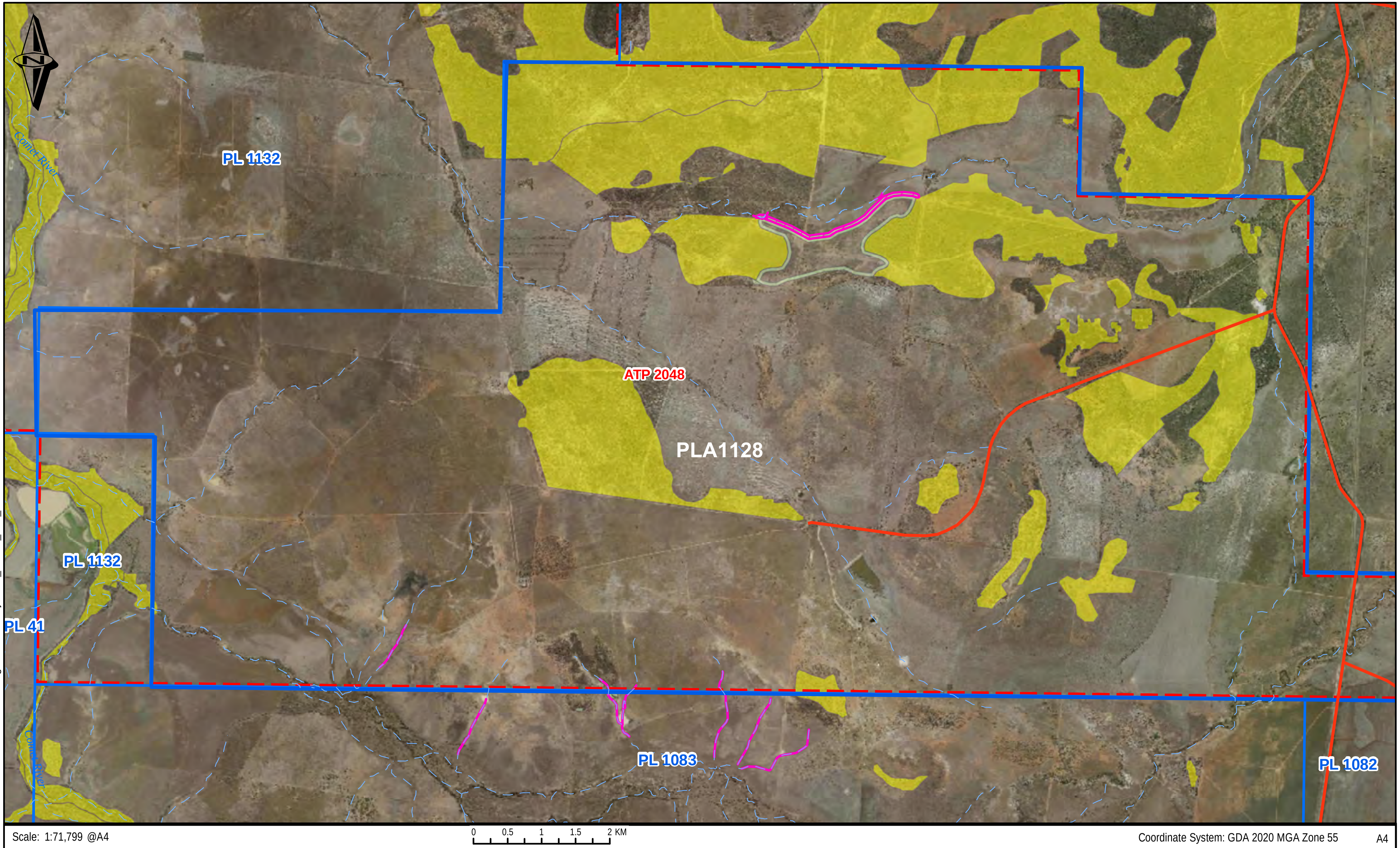

Figure 2. Mapped potential GDEs from the Commonwealth assessment (BOM 2024)

Client: Epic Environmental

Project: Comet Ridge Mahalo Project.

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Kenmore, Qld 4069
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www.3denvironmental.com.au

Drawn By DG Checked DS Date 4/12/2024

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4.0 Summary of Assessment Methods

The field survey included an assessment of 15 sites, all considered to represent potential GDEs from the BOM GDE Atlas (BOM 2024). At each assessment site, sampling of up to five trees for leaf water potential (LWP) was completed, with twig samples collected to analyse xylem stable isotope composition. Five locations were subject to soil auger profiling to facilitate the collection of soil moisture potential (SMP) and stable isotope data from the soil profile. Groundwater sampling was completed as part of a dedicated quarterly groundwater sampling program. All methods are consistent with GDE assessment protocols detailed by Doody et al. (2019) and Richardson et al., (2011).

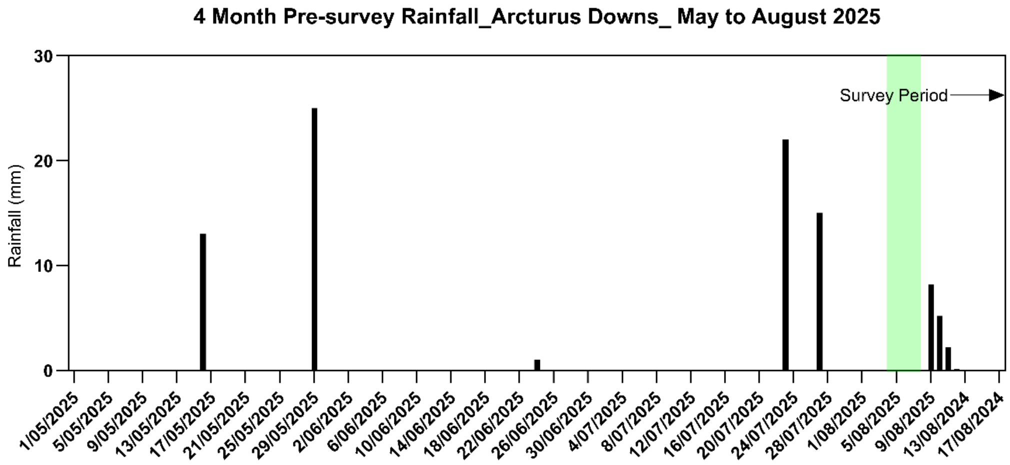

Figure 3. Pre-survey rainfall from the Clermont Airport recording station (BOM035002), the nearest reliable recording station to the assessment area from 1st of May to 17th August 2025.

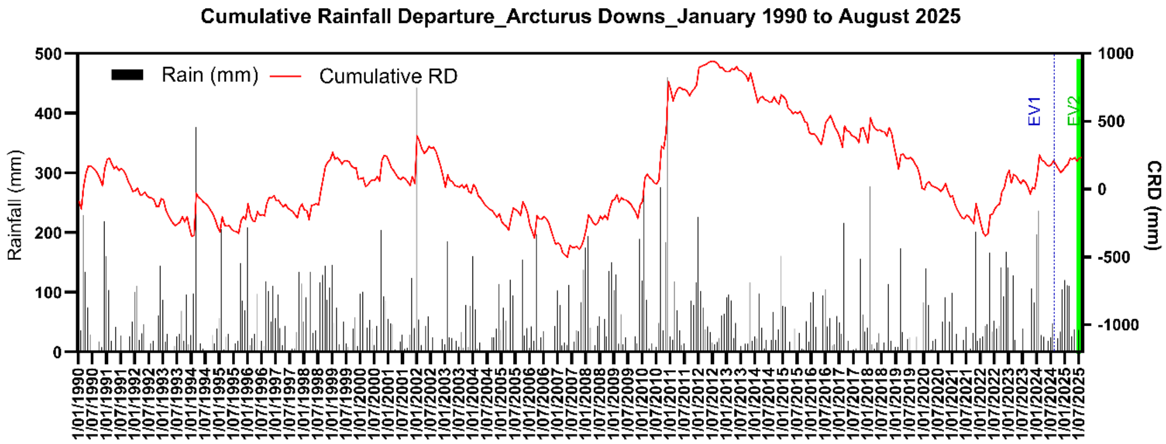

Figure 4. Rainfall trends at the Arcturus Downs expressed as Cumulative Rainfall Departure from January 1990 to 10st August 2025 (SILO 2025).

4.1 Site Selection

The EV2 assessment focused on areas that were sampled during the EV1 asssessment. The EV1 survey focused largely on the Brigalow TEC, and other areas mapped as terrestrial GDEs in the GDE Atlas, including sites where GDEs have been mapped as linear bands on the edges of residual escarpments. **Figure 5** shows sampling localities relative the mapped GDEs and TECs (from Epic, 2024) with **Table 1** providing a summary of the purpose of individual GDE assessment sites, as per the EV1 assessment (Watermark Eco, 2024). GDE assessment sites relative to field verified regional ecosystem (RE) mapping is shown in **Figure 6.**

Table 1. The location of GDE assessment sites and sampling purpose.

GDE assessment site	Landform	Purpose	Targeted RE
1, 4, 8, 12	Residual landform with loamy clay soils (often red)	Sampling of Low Potential Terrestrial GDEs associated with remnant eucalypt woodland habitats.	11.5.3
3	Residual sandy soils over clay and shallow bedrock	Sampling of Low Potential Terrestrial GDEs associated with remnant eucalypt dominant woodlands.	11.5.9
2	Residual landform with loamy clay soils	Investigation of a Moderate Potential Aquatic GDE associated with the margins of a residual escarpment.	Non-remnant
5, 6, 7	Residual clay plains with gilgai development	Sampling of Brigalow TEC patches. All sampled patches are outside mapped Terrestrial GDEs from the GDE Atlas (BOM 2024).	11.4.9 (Brigalow TEC)
9, 10, 11	Residual clay and clay loam plains over shallow basement (sedimentary) rocks.	Sampling of Low Potential Terrestrial GDEs associated remnant eucalypt woodland habitats.	11.4.8
14, 15	Alluvial clays associated with riverine floodplain.	Sampling of Low Potential Terrestrial GDEs associated with mapped occurrences of the Brigalow TEC associated with a riverine floodplain.	11.3.1 (Brigalow TEC)
13	Elevated rocky plateau with a superficial sand covering.	Sampling of Low Potential Terrestrial GDEs associated with lancewood (*Acacia shirleyi*) habitats.	11.7.2

4.2 Leaf Water Potential

Leaf Water Potential (LWP) defines the work required per unit quantity of water to transport it from the moisture held in the soil to leaf stomata. LWP balances osmotic potential, turgor pressure, and matric potential. It is a function of soil water availability, evaporative demand, and soil conductivity. LWP was measured pre-dawn (before sunrise) as per standard protocol. Due to a lack of transpiration, LWP will equilibrate with the wettest portion of the soil, which contains a significant amount of root material. LWP will shift to a lower status pre-dawn as the soil dries out seasonally (Eamus 2006a). Measurement of LWP pre-dawn thus indicates the water availability to trees at each assessment site and whether trees are tapping saturated zones of the soil profile where water is freely accessible or utilising moisture that is more tightly bound to soil particles.

Survey localities were sampled pre-dawn (first light to pre-sunrise), and leaves were collected from three to five mature canopy trees with a 9 m extension pole fitted with a lopping head. Sampling focused on both brigalow (*Acacia harpophylla)*, and other eucalypt species with potential to be a facultative phreatophyte. Collected branches were double bagged in black plastic to avoid moisture loss and sun exposure, and LWP was measured on-site within half an hour of harvest. Leaf material was trimmed with a fine blade and inserted into an appropriate grommet for sealing within a Model 3115 Plant Water Status Console (Soil Moisture Equipment Corp, 2007). The chamber was sealed and gradually pressurised with nitrogen until the first drop of leaf water emerged from the petiole with values represented in millipascals (MPa) for direct comparison to Soil Moisture Potential (SMP) measurements. In total, 32 trees were assessed for LWP across the fifteen assessment sites, with the location of these trees detailed in Section 4.2. The following categories were applied as a measure of relative water availability:

- Extremely High: LWP >-0.276 MPa
- Very High: LWP -0.276 to -0.580 MPa
- High: LWP <-0.580 to -0.896 MPa
- Moderate: LWP <-0.896 to -1.21 MPa
- Low: LWP <-1.21 to -1.72 MPa
- Very Low: LWP <-1.72 to -2.21 MPa
- Extremely Low: LWP <-2.21 MPa

While the defining values of these categories are arbitrary, they indicate the likely degree and nature of groundwater dependence or interaction. The ‘Extremely High’ category would indicate the potential for interaction with a highly fresh groundwater source, with the degree of groundwater interaction decreasing to the ‘Moderate’ category, which may indicate either utilisation of soil moisture from the vadose zone or interaction with saline groundwater. Categories of ‘Low’ to ‘Extremely Low’ are considered unlikely to utilise groundwater to any degree, regardless of salinity. It should also be noted that soil moisture in the ‘Extremely High’ category can be supplied directly from unsaturated portions of the soil profile depending on moisture availability, which can be assessed by measuring SMP.

4.3 Soil Moisture Potential

A hand auger was utilised to collect shallow soil samples at regular depths down the soil profile at selected sites and opportunistic sampling of groundwater where intersected. Selection of sites for auger placement considered:

1. Whether LWP measurements indicated a higher degree of water availability in the soil profile than other assessment localities, suggesting that shallow groundwater or a soil zone of higher matric potential exists at depth (i.e. a sand lens may be present in the soil profile).
2. The representativeness of a particular chosen site as a means to provide information that applies to other assessment localities.

At each site chosen for auger sampling, the aim was to collect soil samples to the maximum depth of the auger of penetration, with penetration often arrested by coarse gravel / cobble substrates, large tree roots, or refusal at relatively shallow depths in the soil profile due to a high density of root material. Observations taken for each auger hole included:

1. Soil structure, colour, and texture.
2. Presence of root matter.
3. Soil moisture/water and areas of saturation.

Soil sampling was undertaken at regular intervals down the soil profile for analysis of stable isotopes of oxygen ($\delta^{18}O$) and deuterium ($\delta^{2}H$), and duplicate samples were retained for analysis of SMP.

Sample collection was generally spaced at 0.5 m down the auger profile, with additional samples taken where changes in soil structure/texture, moisture content, or zones of tree roots were intersected. Samples were sealed in airtight plastic vials and placed on ice for later measurement of SMP.

SMP, which includes the matric (water availability) and osmotic (saltiness) potential, measures the energy required to extract moisture from the soil. Water can only move down a hydraulic gradient from soil to root (Gardner, 1960). Areas in the soil profile with a less negative SMP than measured pre-dawn LWP will be accessible as a source of moisture. Large, mature trees are unable to extract moisture from regions in the soil profile where the total SMP is significantly below LWP measured in pre-dawn leaf material (Feikema et al., 2010; Lamontagne et al., 2005; Thorburn et al., 1994; Mensforth et al., 1994; Holland et al., 2009 and Doody et al., 2015). The maximum suction roots for crops can apply to soil/rock before a plant wilts due to a negative water supply is approximately -15 bars or -1.5 MPa (or -217.55 psi). This wilting point is relatively consistent between all plant species. However, many Australian plants have adapted to conditions of low water availability and can persist strongly in soil conditions where moisture potential is below standard wilting point (Eamus, 2006a). As a general measure, however, where measured LWP is below the standard wilting point, it indicates plant water deficit, and the tree is unlikely to be supported by a saturated water source regardless of groundwater salinity.

Soils were sampled at regular intervals down a soil profile for measurement of SMP, with sampling intervals dependent on the degree of structural and lithological heterogeneity. The measurement of SMP was completed in the laboratory with a portable Dew Point Potentiometer (WP4C) (Meter et al., 2021). The WP4C meter uses the chilled mirror dew point technique with the sample equilibrated within the headspace of a sealed chamber that contains a mirror and a means of detecting condensation on the mirror. Soil moisture potential samples were measured in millipascals (mPa). A 7 ml soil sample was inserted into the WP4C meter using a stainless-steel measuring tray.

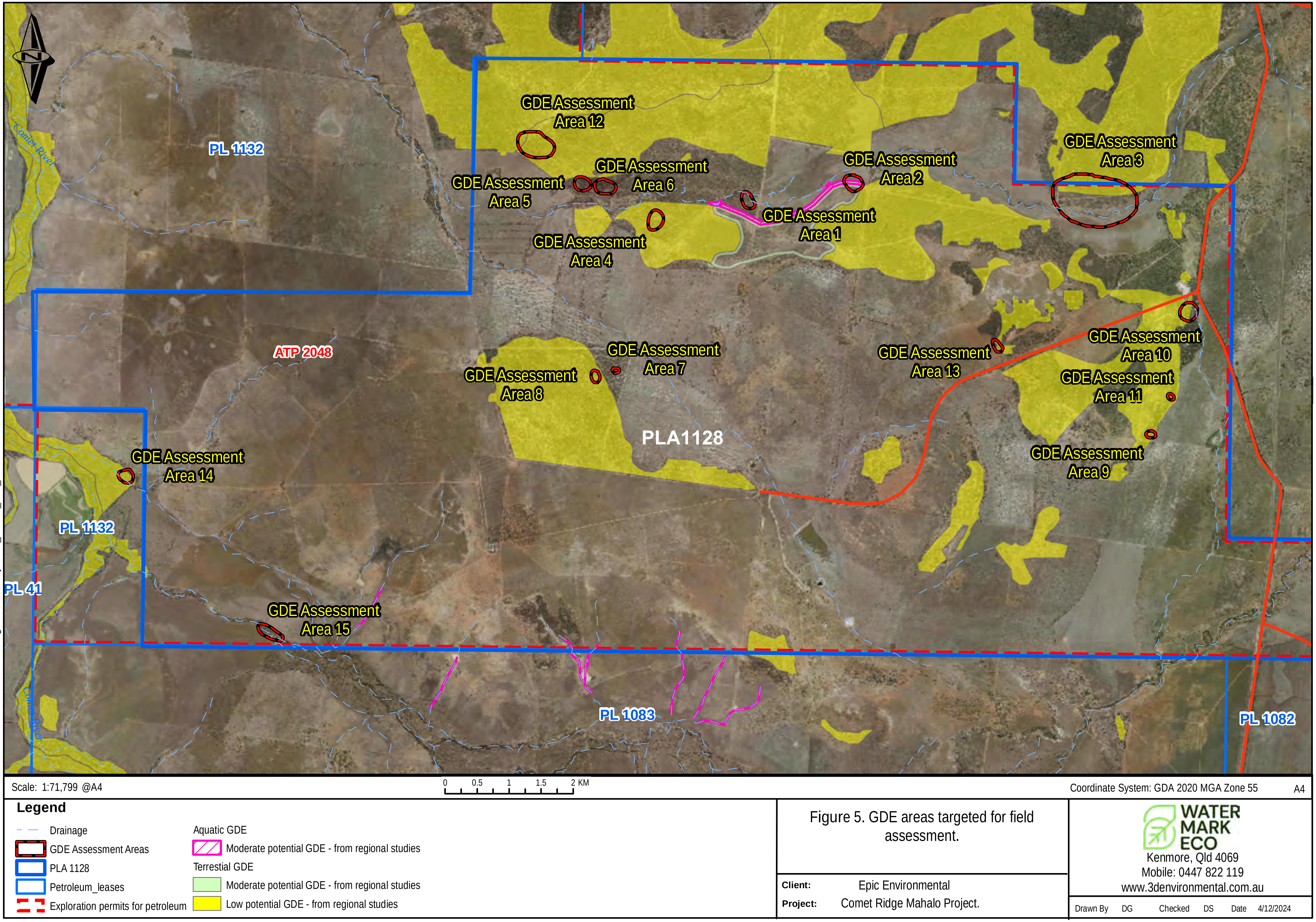

Figure 5. GDE areas targeted for field assessment.

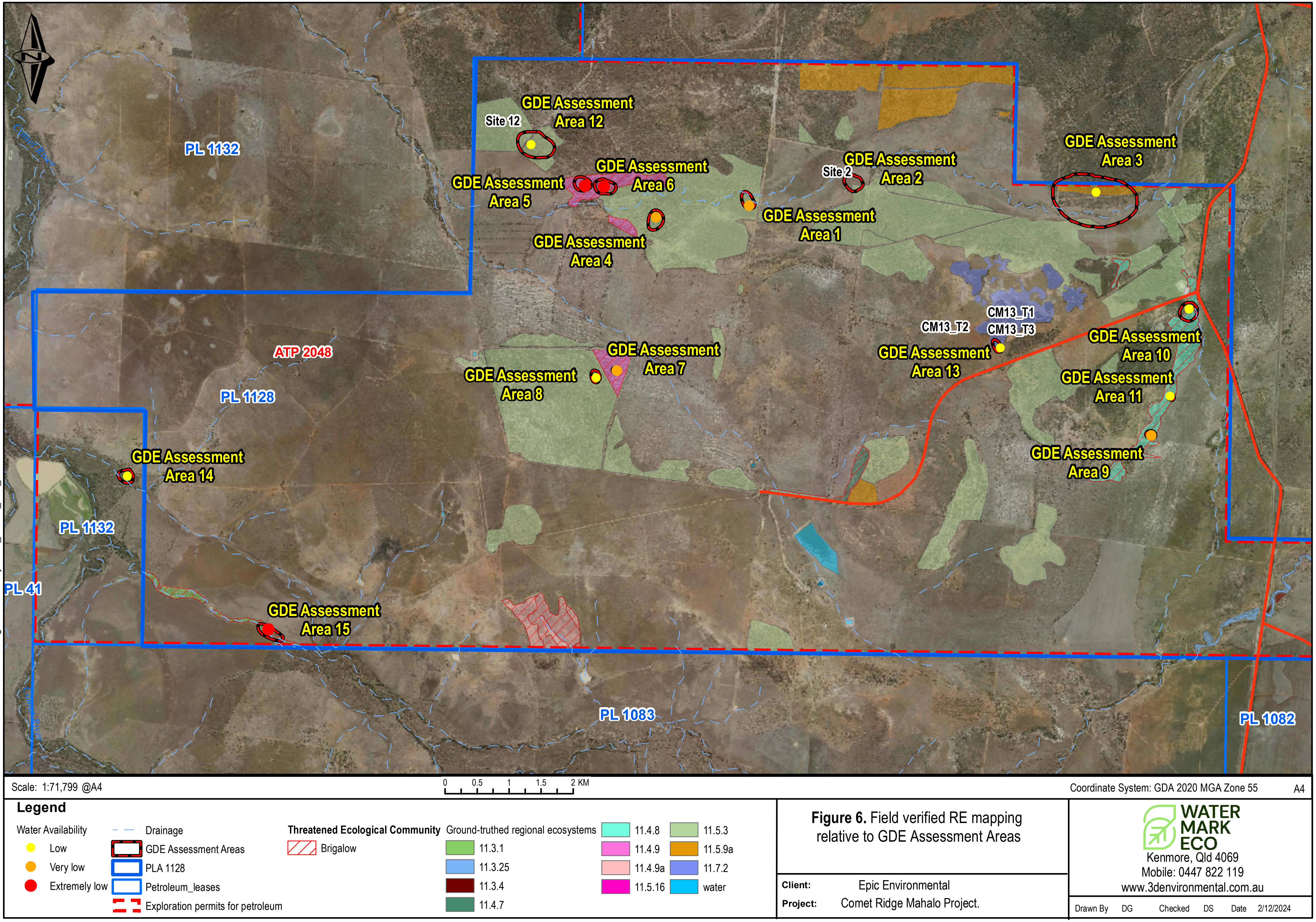

Figure 6. Field verified RE mapping relative to GDE Assessment Areas

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4.4 Stable Isotope Sampling and Analyses

Trees may utilise water from various sources including the phreatic zone (saturated zone), the vadose zone (unsaturated zone) and surface water. The stable isotopes of water, oxygen 18 ($\delta^{18}O$), and deuterium ($\delta^{2}H$) are valuable tools to help define terrestrial vegetation's predominant water source. The method relies on a comparison between the stable isotope ratios of water contained in plant xylem (from a twig or xylem core) with stable isotope ratios found in the various sources of water, including a shallow groundwater table, potential sub-artesian aquifer water sources or shallow soil moisture. Methods used to assess stable isotopes are detailed below.

4.4.1 Local Meteoric Water Line

Data interpretation is supported by incorporating isotopic data from rainfall collected in the Bowen Basin between 2018 and 2022, which is applied to construct a best-fit Local Meteoric Water Line (LMWL) using simple linear regression (Craig, 1961). The constructed LMWL defines a slope of 6.852 and d-excess of 9.776 ($Y = 6.852*X + 9.776$) which is shallower than the Global Meteoric Water Line (GMWL) which defines a slope of 8 and d-excess of 10 ($Y = 8*X + 10$) (Crosbie et al 2012). While construction is based on a limited number of samples (9 in total as per **Appendix D**), the data provides sufficient utility to support development of a preliminary LMWL for northern Bowen Basin

4.4.2 Soil Moisture Isotopes

Sampling was undertaken regularly in auger holes to capture isotopic signatures from a range of potential plant moisture sources from the upper soil surface to the top of the phreatic zone in shallow water tables. The sampling intervals for soil moisture isotope analyses depended on auger yield and soil variation. In general, the initial soil sample was taken within the top 0.2 m of the soil profile, and subsequent samples were taken at 0.5 m intervals down the soil profile to the end of the hole, mirroring the interval for SMP. Approximately 200 milligrams (mg) of soil was collected for isotope analysis, sealed in airtight plastic sampling containers, double-sleeved in click-seal plastic bags, and placed on ice for storage prior to dispatch to the Australian National University (ANU) Stable Isotope Laboratory for analysis where they were snap frozen until analysis was complete.

Soil intervals selected for stable isotope analysis include where tree roots were recorded, exceptionally moist intervals, or at the base of the auger hole where high soil moisture/groundwater was recorded. In most cases, isotopic sampling of complete profiles was undertaken to aid data interpretation.

4.4.3 Xylem Water Isotopes

Twigs were collected from the outer canopy branches of target trees used to sample LWP. The following sampling procedure was applied:

1. Harvesting of outer branches of trees of the target tree at the GDE assessment site was completed, with two duplicate samples prepared from each branch for analysis.
2. The position of trees subject to assessment was marked with a GPS, and structural measurements, including height and diameter at breast height (dbh), were recorded.
3. Outer branches from each tree were harvested with an extendable aluminium pole.

4. Stem material approximately 5 cm in length was sourced with stainless-steel secateurs.
5. The bark was immediately removed, and stems were sealed in wide-mouth sample containers with leakproof polypropylene closures (approx. 125 ml volume). They were immediately labelled with the tree number and placed in an iced storage vessel prior to dispatch to the ANU Stable Isotope Laboratory.
6. Upon receipt of samples at the ANU Stable Isotope Laboratory, samples were snap-frozen (-18 degrees Celsius) until analysis.
7. Samples were taken from the xylem to be as close to the centre of the twig as possible. Extracted water was analysed using a Picarro L2140i cavity ring-down spectrometer for both xylem and soil samples.

The collection of twig samples occurred from multiple trees at each assessment site, consistent with trees assessed for LWP. Sampled portions of branches with a minimum diameter of 1 cm were debarked and then trimmed to approximately 5 cm in length. The debarked sections were sealed in 2.5 x 5 cm clip-sealed bags, then individually placed into airtight 30 ml polypropylene sample containers, on ice, and frozen within 2 hours of collection. Freezing prevented water dispersal between the xylem and the phloem during storage, thus eliminating a potential source of error resulting from considerable partitioning of isotope ratios across a twig cross-section. There is also potential for fractionation of stable isotope values, particularly δ2H, during movement of water through the xylem from roots to leaves (Evaristo et al, 2017; Petit & Froend, 2018). As fractionation will likely result in isotopic enrichment rather than depletion, the least enriched sample from each tree is considered most likely to be representative of the soil moisture or groundwater source (Hilary Stuart-Williams – ANU Farquhar Laboratory personal communication, July 25, 2019).

4.4.4 Water Sampling

To compare the isotopic signature of groundwater to that of vegetation, water samples were collected from various sources including:

- Surface waters.
- Selected developed groundwater monitoring bores (in cases, previously sampled by RDM Hydro) including those specifically installed as GDE monitoring bores.

All samples were dispatched to ANU to analyse stable isotope composition. Six dedicated GDE monitoring bores were installed to measure standing water levels (SWLs), water quality, and seasonal variation, as provided in **Table 2**. The location of all groundwater bores, including DNRM Registered bores, is shown in **Figure 7** relative to mapped GDEs. SWLs for the various formations. Data from bore construction reports indicates:

- The shallowest groundwater levels reported are 7.97 metres below ground level (mbgl) at monitoring well MN-MB1-a, southwest of PLA 1128. The groundwater salinity reported for this monitoring well is 33 400 µS/cm.
- More typical groundwater depths range from 20 to 22 mbgl, with groundwater associated with sandstone intervals in the Rewan Formation. Groundwater is typically saline with reported salinities from 30 000 to 51 900 µS/cm (MN-MB6-b and MN-MB5-R).

- Three installed monitoring wells were dry or produced insufficient water to draw a sample.

Groundwater monitoring completed by Terra Sana Consultants on Meroo Downs and Togara (Terra Sana Consultants, 2025a & 2025b) between November 2024 and September 2025 report:

- SWL for bore MN-MB1-a ranged from 10.58 to 11.64 mbgl with EC ranging from 17 162 to 32 887 µS/cm.
- SWL for bore MN-MB6-b ranged from 23.4 to 24.66 mbgl with EC ranging from 21 829 to 37 443 µS/cm.

Both MN-MB1-a and MN-MB6-b have been temporally sampled for stable isotope composition, with bailer sampling completed in conjunction with the EV2 assessment.

Table 2. Bore target formation, standing water level (SWL), and general water quality for dedicated GDE monitoring bores at the time of well development.

GDE Monitoring Bore Temp ID	Y	X	Constructed Depth (m)	Screen Depth (mbgl)	Formation/ Screened Interval	SWL (mbgl)	Field EC (µS/cm)
MN-MB6-b	-24.02003	148.62113	30	23.0 – 23.9	Sandstone – Mudstone (Rewan Formation)	21.36	30 000
MN-MB4-b	-24.03918	148.61745	20	16 - 19	Clay – siltone – sandstone (Rewan Formation)	19.98	Insufficient water to sample
MN-MB5-R	-24.03926	148.61826	35	34.1	Silstone – sandstone (Rewan Formation)	21.46	51 900
MN-MB3-a	-24.0671	148.71576	25.1	18.3-24.3	Mudstone – Rewan Formation	Dry	-
MN-MB1-a	-24.06602	148.55875	17.1	10.1 - 16.1	Interface between alluvium and siltstone (Rewan Formation)	7.97	33 400
MN-MB2-b	-24.06597	148.55866	24	-	Hole abandoned due to adverse locations. Dry to drilled depth.	Dry	-

4.5 Data Reconciliation and Interpretation

Data interpretation followed a structured approach by filtering multiple lines of evidence to assess groundwater dependence. The biophysical measurement of LWP formed the primary assessment, followed by the adjunct comparison with SMP, with stable isotope data used to provide supplementary evidence where ambiguity remained. In addition, an overview of the depth of the groundwater table and groundwater salinity was completed as a final filter to determine the accessibility of groundwater and suitability as a source of moisture to support transpiration at each assessment locality.

Step 1. LWP: An initial comparison of individual trees' LWP values within the expected range for known terrestrial GDEs subject to various salinity regimes, assuming complete saturation of sediments in the groundwater table and minimal influence of soil matric potential, is applied. This data is derived from a range of published sources, including Jones et al. (2020), Holland et al., (2009), and Mensforth et al., (1994):

- Expected LWP for trees in equilibrium with a fresh to brackish saturated source of moisture (EC<1500 μS/cm) = >-0.2MPa.
- Expected LWP for trees in equilibrium with a moderately saline soil moisture source (EC>1500 to 10 000 μS /cm) =-0.2MPa to -0.55MPa.
- Expected LWP for trees in equilibrium with a saline soil moisture source (EC>10 000 to 30 000 μS /cm) = -0.55MPa to -1.5MPa.

Where groundwater regimes exhibit varying salinity regimes, this greatly increases the complexity and uncertainty of LWP assessments, meaning much greater reliance on other analytical tools, such as stable isotopes. However, trees that demonstrate LWP values that are considerably more negative than expected ranges for the local groundwater salinity regimes are assumed not to exhibit any significant degree of groundwater dependence. From the range of groundwater salinities recorded from monitoring bores, sites with average LWP <-1.5 MPa (standard wilting point) were not subject to further scrutiny other than for comparative purposes. Groundwater with salinity > 30 000 μS /cm is considered an unsuitable source of moisture for most trees and unlikely to be utilised by deep rooted vegetation.

Step 2. Soil Augering and SMP: Soil augering is helpful for a) direct observation of soil physical properties including depth to bedrock; b) physical observation of distribution of tree roots down within the soil profile; c) identification and sampling of shallow groundwater tables; and d) measurement of soil biophysical properties including SMP. For trees where LWP was within the expected range of values for GDEs under specific local salinity regimes, soil augering allowed the direct observation of the physical features of the soil profile, as well as facilitated measurement of SMP to identify the likelihood that moisture for transpiration was being supplied from the upper soil profile, or whether deeper sources of moisture may exist. As described in **Section 3.3**, water can only move down a hydraulic gradient from soil to root, meaning that only those portions of the soil profile with an SMP that is less negative than measured pre-dawn LWP will be accessible as a source of moisture (Gardner, 1960). This does not provide an absolute assessment of groundwater dependence, though it identifies potential sources of moisture to give context to evaluating stable isotopes (Step 3). SMP data is only available at some sites, increasing the reliance on stable isotopes during data reconciliation.

Step 3. Stable Isotope Signatures: For trees that demonstrate potential groundwater dependence from LWP measurements, stable isotope signatures from the xylem samples were compared to signatures from groundwater, surface water from residual and permanent pools, and soil moisture (where this data was available) to provide a fingerprint for the source of moisture being utilised. Where three lines of evidence indicated utilisation of a groundwater source, the tree was generally accepted as being groundwater dependent. Where ambiguity remained in the assessment, additional features were considered, including site-specific geology, geomorphology, soil physical properties, groundwater salinity, and depth to the water table at the location to inform the final assessment of groundwater dependence for any tree or site.

4.6 Limitations and Other Information Relevant to the Assessment

This assessment provides a subsequent assessment of ecohydrological processes at each of the fifteen GDE assessment sites, for the purpose of assessing temporal consistency in the conclusions drawn from EV1, under comparable climatic conditions. The dry-season timing is considered optimal for the assessment of GDE function, with representative areas chosen for GDE sampling due to the extensive nature of data collection otherwise required. These areas serve as a basis for extrapolation over broader areas with similar ecohydrological function. While the conclusions drawn from two rounds of field data collection are considered an accurate representation of the broader GDE function across the Mahalo North Project area, it is not possible to discount exceptions and variations to the ecohydrological concepts presented within.

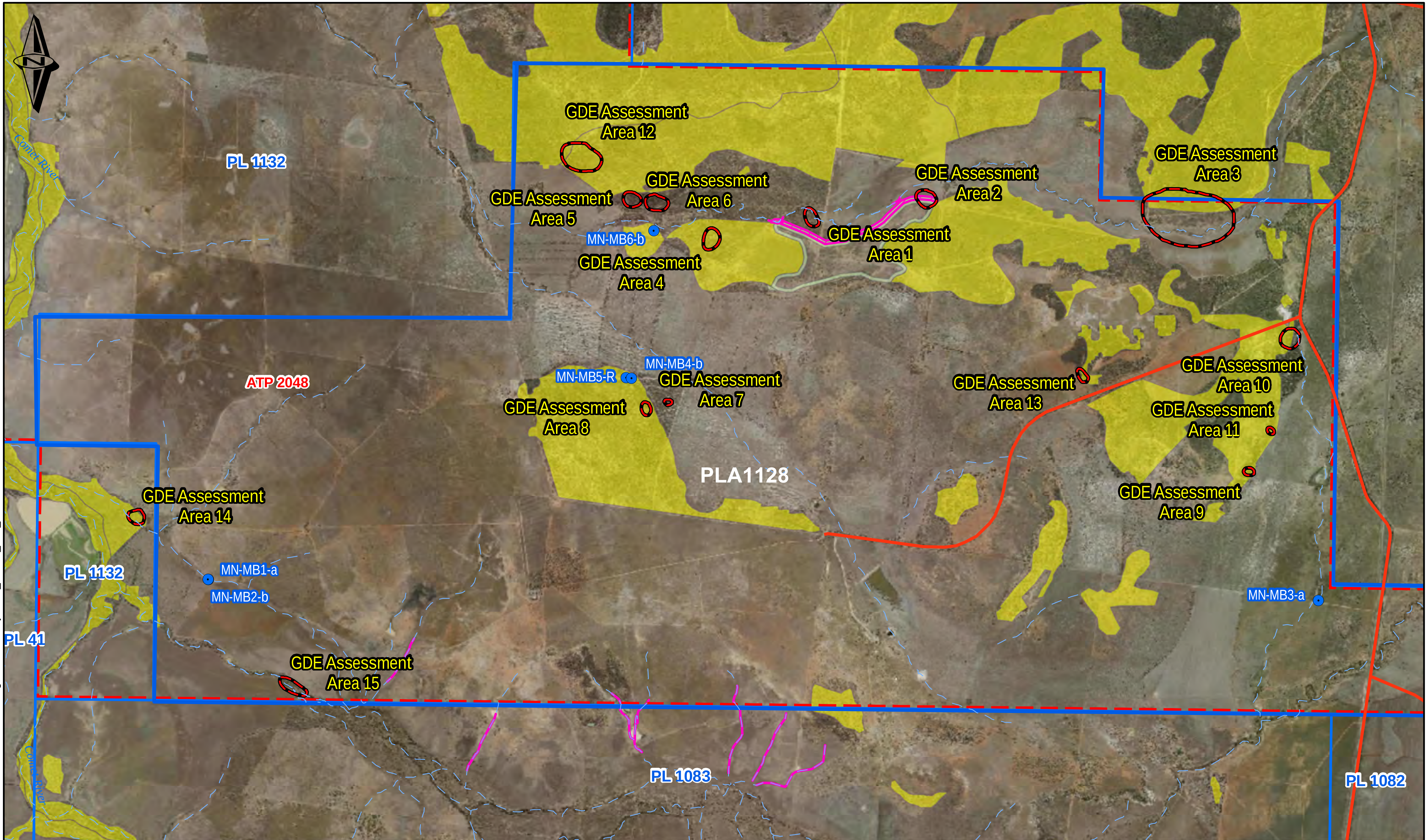

Figure 7. Groundwater monitoring bores relative to mapped GDEs

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5.0 Site Level Ecohydrology

The following section provides an overview of the ecohydrological characteristics of the major tree species associated with REs 11.3.1, 11.4.8, 11.4.9, 11.5.3, 11.5.9a and RE11.7.2, which were sampled during the field assessment due to their representation as potential GDEs in the GDE Atlas (BOM, 2024).

5.1 Eucalypts

Four eucalypt species were sampled during the GDE assessment, being poplar box (*Eucalyptus populnea*) in RE11.5.3, coolabah (*Eucalyptus coolabah)* as a canopy emergent within RE11.3.1, Dawson gum *(Eucalyptus cambageana)* as a canopy dominant in RE11.4.8 and a canopy emergent within RE11.4.9, and silver-leafed ironbark (*Eucalyptus melanophloia)* as a dominant canopy tree in RE11.5.9.

Coolabah: *Eucalyptus coolabah* favours sites with heavier clay soils, typically close to drainage lines and requires flooding for regeneration (Roberts 1993). There are few studies that attempt to detail the moisture sources and usage strategies of *Eucalyptus coolabah.* Costelloe et al., (2008) suggest that coolabah avoids using saline groundwater via the following mechanisms:

1. Growing at sites that maximise the frequency of soil moisture replenishment (i.e. on drainage lines and overflow channels).
2. Having extremely low transpiration rates.
3. Strong capacity to extract moisture from soils with extremely low osmotic / matric potentials.

Costelloe et al., (2008) concluded that coolabah avoided using hypersaline groundwater (71 000 mg/L[Cl] or 70 290 µs/cm), instead favouring the use of low salinity soil moisture in the vadose zone above the groundwater table. Coolabah can however continue to extract moisture at Cl concentrations up to 30 000 mg/L (~27 800 µS/cm) in soils where matric potential in the upper soil profile is extremely low due to a combination of extreme drying coupled with a clayey substrate.

The heavy clay soils that support the Brigalow TEC place a physical limitation on tree root penetration. Clay substrates are an unsuitable medium for development of a deep tap root system that would be necessary to penetrate to the groundwater table (Dupuy et al., 2005) and soils with low hydraulic conductivities, such as clays, greatly limit the ability of trees to utilise groundwater (Feikema et al., 2010). Hence it is not expected that coolabah would have the same capacity to develop the deeper tap roots that characterise river red gum, and maximum rooting depth would be considerably shallower, most likely considerably less than 10 m.

Other Eucalyptus Species: All eucalyptus species are potential users of groundwater (Cook et al 2007) although few studies demonstrating this dependence exist. Fensham and Fairfax (2007) consider poplar box, and silver leaf ironbark (*Eucalyptus melanophloia)* to possess a shallow rooting system with limited investment in deep root architecture, rendering them susceptible to droughting. Poplar box is more typically associated with upper terraces that are elevated above the river channel requiring a deeper rooting system to access groundwater. Silver leaf ironbark generally occupies more elevated portions of the landscape, away from drainage lines where depth to groundwater would be greatest. For Dawson gum (*Eucalyptus cambageana)*, the general association of the species with heavy clay soils and brigalow suggests that there will be limited development of deeper sinker roots. It is expected that species ecology will be similar to poplar box and coolabah, with a strong association with heavy clay soils, presenting a physical limitation on tree root penetration (Dupuy et al., 2005).

5.2 Acacia's

Brigalow (*Acacia harpophylla)* habitats and individual trees regularly occur adjacent to the floodplain of the major drainage systems and generally occupy heavy clay soils (vertosols) with well-developed gilgai microtopography in the upper soil profile (0.6 m to surface) where the bulk of nutrient recycling occurs. The subsoil components are however typically strongly cohesive clays with high levels of salinity, sodicity, acidity and phytotoxic concentrations of chloride which may reduce the effective rooting depth in these soils (Dang et al., 2012). Johnson et al., (2016) describe brigalow as *'a clonal species with stems arising from horizontal roots which draw resources from a substantial area around the plant'*. The concentration of the brigalow root mass in the upper soil profile enables the species to resprout profusely from horizontal roots after physical disturbance and limits the capacity for other woody species to compete for moisture and nutrients. Brigalow's shallow rooting habit is evident with the tendency of mature trees to topple because of churning in the upper soil profile with fallen trees universally exposing a well-developed lateral root system with little evidence for development of deeper sinker roots that would have capacity to propagate to deeper groundwater tables. Brigalow is not considered to represent groundwater dependent vegetation.

Unlike brigalow, lancewood (*Acacia shirleyi*) is associated with rocky substates with skeletal soils, typically on lateritic plateaus and outcrops. There is no evidence that lancewood has capacity to utilise groundwater to any degree.

5.3 Summary - Depth of Tree Rooting and Salinity Tolerances

As described in previous sections, tree rooting depth is a difficult parameter to predict and measure as it depends on several factors including tree species, substrate, edaphic conditions, as well as depth to groundwater. Tree root penetration is typically arrested at the capillary fringe (Eamus et al 2006b). DNRME (2013) considers 20 m to represent the maximum potential rooting depth of river red gum (*Eucalyptus camaldulensis)*, the species where the most information on tree rooting depth has been obtained, although this would likely only occur under optimal conditions with favourable soil types and moisture unencumbered by salinity. As previously discussed, other authors have suggested much shallower maximum rooting depths including Jones et al (2020) at 8.1 mbgl based on physical observation and Horner et al. (2009) at 12–15 mbgl and Doody et al., (2019) suggests that vegetation will only consistently utilise groundwater where it occurs at depths of <10 m below the land surface. Based on these observations, it is unlikely that river red gum would be utilising a groundwater table deeper than 15 mbgl, and for other species including coolabah, poplar box, silver leaf ironbark, Dawson gum and brigalow, the groundwater depth threshold would be considerably shallower (<10 m).

Based on evidence from published literature (Costelloe et al., 2008; Thorburn et al., 1994, Mensforth et al., 1994) and the Watermark Eco's experience, it is unlikely that the terrestrial woody vegetation that characterises the study area would have capacity to utilise groundwater that has salinity greater than 30 000 µS/cm, instead relying on whatever fresh moisture that can be extracted from the vadose zone. It is also unlikely that any tree would invest in the development of a deep root system to tap water from a saline water table, where the benefits in terms of increased water availability would be very marginal.

6.0 Results

6.1. Leaf Water Potential

Figure 8 shows the average LWP values for the fifteen GDE assessment sites with comparison between EV1 and EV2. **Figure 9** represents the LWP values for individual trees from the two survey events, and **Figure 10** provides a spatial representation of average LWP values from EV2. Consistent with LWP data from the EV1 assessment, the EV2 data demonstrates that average LWP values at most sites lie below the standard wilting point, spanning Low to Extremely Low moisture availability ranges. Comparison between EV1 and EV2 indicates only minor differences between the datasets that are not statistically significant ($t(103.9) = 0.6682, p=0.4928$), while all values for the EV2 assessment fall at or below standard wilting point (-1.15 MPa).

- In agreement with the EV1 assessment, sites associated with the Brigalow TEC, including RE11.4.9 (Sites CM_S5, CM_S6 & CM_S7), RE11.4.8 (CM_S4, CM_S9, CM_S10 & CM_S11), and RE11.3.1 (CMS_14 & CMS_15) have LWP values that fall within the Very Low to Extremely Low range (-1.74 to -3.4 MPa). These sites are unlikely to be associated with any degree of groundwater dependence. **Figure 10** demonstrates that brigalow consistently has the lowest moisture availability of all trees, particularly at Sites CM_S5 and CM_S6, indicating the species' tolerance to extremely dry edaphic conditions. Coolabah and Dawson gum, growing in association with brigalow, demonstrate a similar range of LWP values across all assessment sites, generally falling close to or below standard wilting point with the highest LWP value for the two species at -1.4 MPa, coincident with site CMS7 and CMS14 respectively. A single specimen of narrow-leaf bottle tree (*Brachychiton rupestris)* at site CMS_7 (CMS7_T5a) presents an extremely high LWP value of -0.5 MPa.
- LWP values at site CM_S3, associated with silver leaf ironbark (RE11.5.9), are considerably more negative in EV2 than reported in EV1, decreasing from an average -1.1 MPa to -1.9 MPa between the two assessments.
- Average LWP values for the lancewood (RE11.7.2) dominant site CM_S13 are consistent between assessments at -1.4 and -1.5 MPa for EV1 and EV2 respectively. The average LWP values for the lancewood dominant site retain the highest (least negative) LWP values of any assessment site in EV2, consistent with the results of EV1.

- Poplar box woodlands at Sites CM_S1 and CM_S12 fall below standard wilting point, at -2.3 and -1.8 MPa respectively for the EV2 assessment, consistent with values reported for EV1. In contrast to other trees at site CMS_7, a single specimen of narrow-leaf bottle tree (CMS7_T4) presents a Very High LWP value of -0.5 MPa,

In agreement with the results of EV1, the data indicates low to extremely low moisture availability across all habitats, suggesting that the potential for groundwater reliance is extremely low across PLA 1128, and brigalow is reliant on soil moisture held within characteristically tight clay soils. **Section 5.2** examines edaphic controls on moisture availability, which may account for the significantly higher moisture status demonstrated for silver leaf ironbark (CM_S3) and lancewood (CM_S13).

Table 3 provides an initial assessment of the likelihood of groundwater utilisation for all sites comparing results of the EV1 and EV2 assessment. The potential for those trees with LWP values <-0.55 to utilise groundwater becomes increasingly unlikely as LWP values become more negative, although saline groundwater may complicate this. Based on this data, however, any degree of groundwater dependence for brigalow dominant and co-dominant habitats, including trees associated with RE11.3.1, 11.4.8, and 11.4.9, seems extremely unlikely. **Appendix A** provides a structural summary of all trees assessed for LWP in the EV2 assessment.

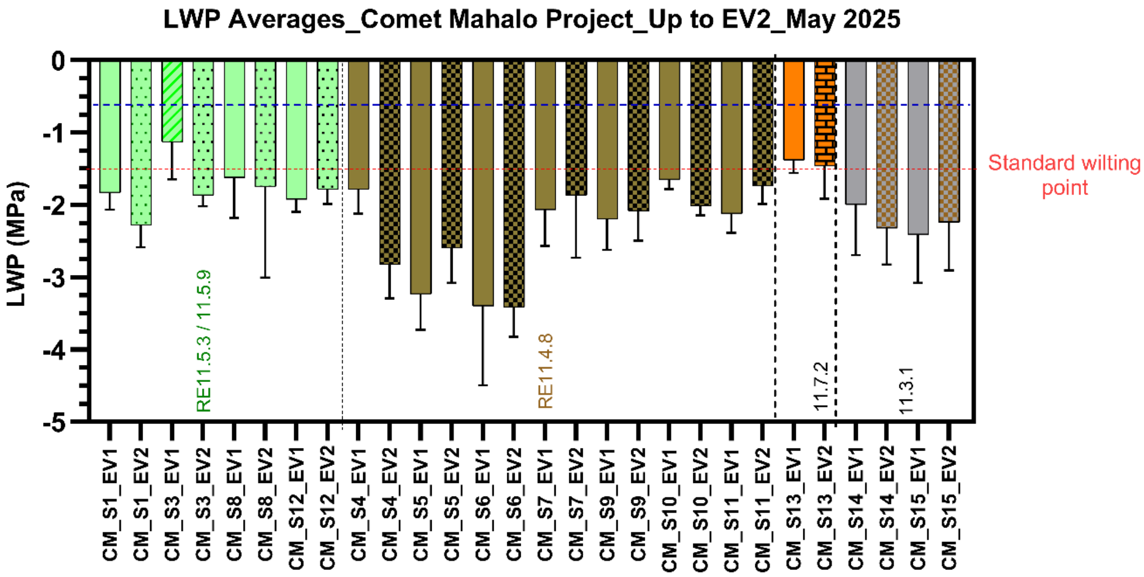


Figure 8. Average LWP values for all assessment sites with the blue dashed line indicating extremely high moisture availability, and the red dashed line indicating Standard Wilting Point (for reference). Patterned bars represent EV2 data.

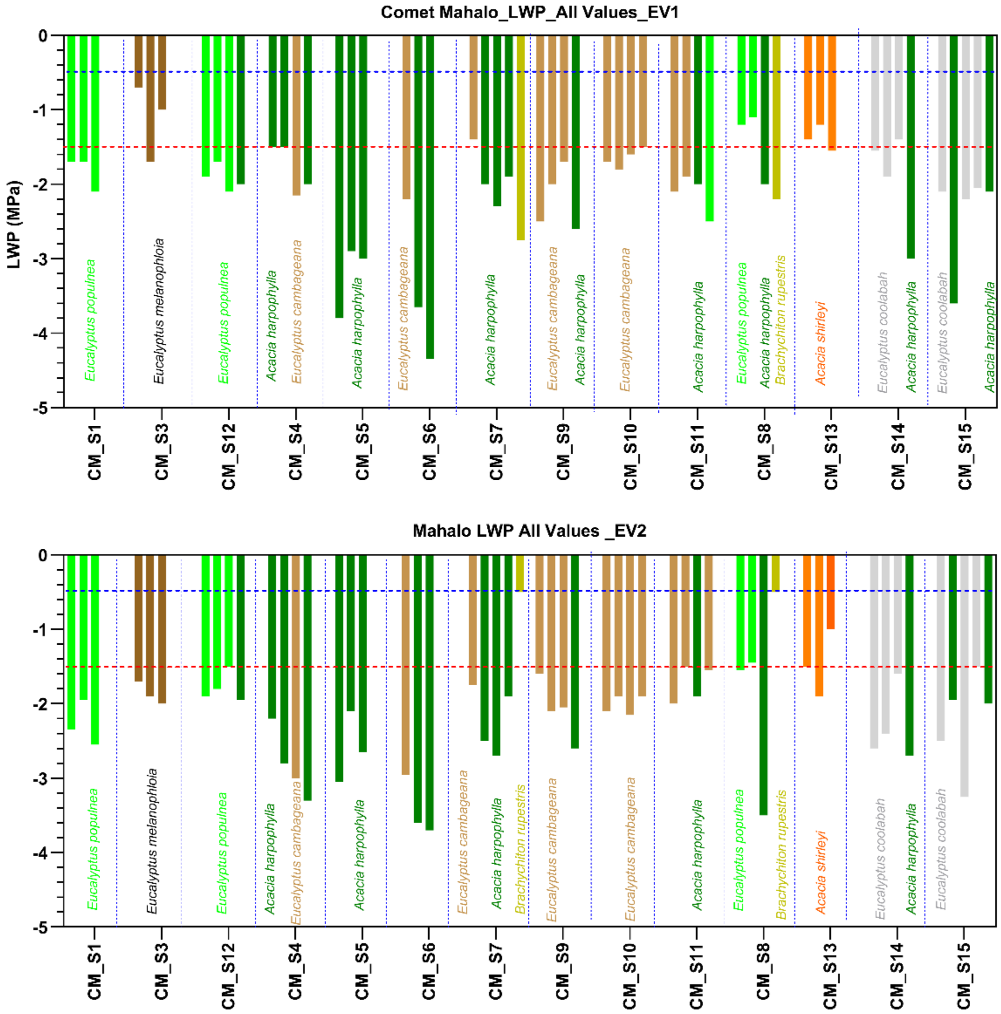
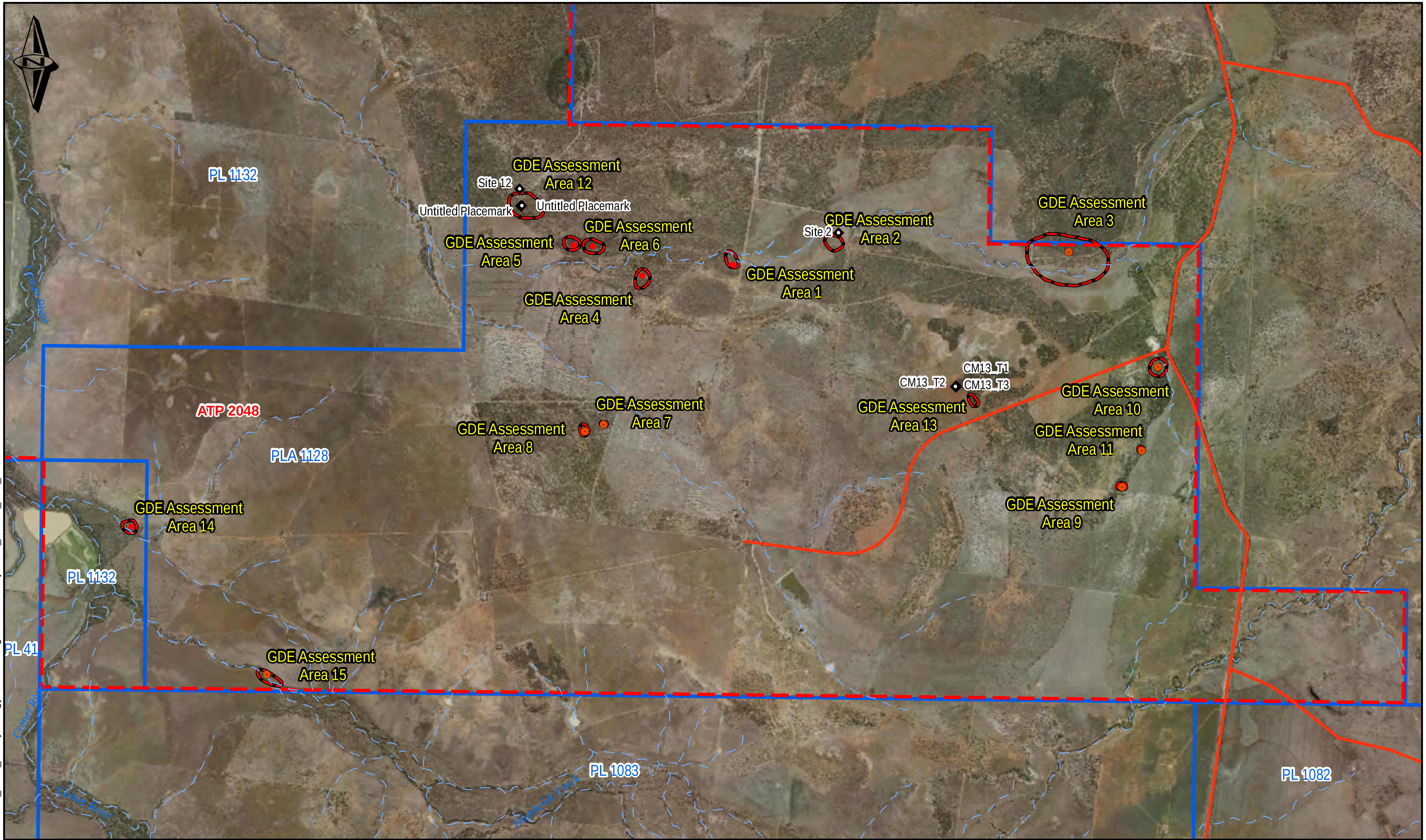


Figure 9. LWP values for individual trees across all assessment sites for the EV1 (top) and EV2 (bottom) assessments. The blue dashed line indicates extremely high moisture availability, and the red dashed line indicating Standard Wilting Point (for reference).



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Scale: 1:80,385 @A4

0 0.5 1 1.5 2 KM

Coordinate System: GDA 2020 MGA Zone 55

A4

Legend

Tree Water Availability
- Very Low
- Extremely Low

Drainage
Exploration permits for petroleum
GDE Assessment Areas
Petroleum_leases

Figure 10. Average LWP values for GDE assessment sites.

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Table 3. Summary details and results of LWP assessment for each GDE assessment site.

Site	LWP Range (MPa) – EV1	LWP Range (MPa) – EV2	Water Availability (EV2)	Comments
RE11.5.9 – *Eucalyptus melanophloia*				
CM_S3	-0.7 to -1.7 MPa	-1.7 to -2.0	Low to Very Low	LWP values have decreased significantly between EV1 and EV2 with the highest EV2 value (-1.7 MPa) suggesting limited potential for groundwater utilisation. The shallow root system of silver leaf ironbark (Fensham & Fairfax. 2007) suggests that trees are most likely accessing moisture in the shallow soil profile rather than deeper groundwater sources. Further evidence from soil moisture profiling and stable isotopes is required to confirm moisture sources at this GDE assessment site.
RE11.5.3 – *Eucalyptus populnea*				
Site CMS_1, CMS_8, CMS_12	-1.1 to -2.1 MPa	-1.45 to -2.55 MPa	Low to Extremely Low	The sampled poplar box at sites CM_S1 and CM_S12 have LWP values in the Low (-1.5 MPa) to Extremely Low (-2.5) range indicating limited moisture availability and limited potential for groundwater utilisation. For Site CM_S8, the slightly higher LWP values for poplar box (--1.5 MPa) similarly suggest limited potential for groundwater usage. The shallow rooting systems of poplar box suggest that these trees are more likely utilising soil moisture from unsaturated regions of the soil profile. A single narrow-leaf bottletree (*Brachychiton rupestris)* (T4) has a very high LWP at -0.5 MPa, indicating Very High moisture availability, warranting additional scrutiny in the soil moisture and isotope analysis study components. The most relevant groundwater monitoring bores for these ecosystems are MN-MB4-b, MN-MB5-R, and MN-MB6-b, which have SWLs ~ of 21.5mbgl and salinities ranging from 30 000 to 51 900 µS/cm. Neither of these values renders groundwater a suitable source of moisture to support transpiration. No indication of groundwater utilisation at any of these assessment sites is given based on highly negative LWP values and unsuitable groundwater sources. However, scrutiny of complementary datasets is required to explain the Extremely High moisture availability for the single narrow-leaf bottle tree.
RE11.3.1 (Brigalow TEC) – *Acacia harpophylla / Eucalyptus coolabah*				
Site CM_S14, CM_S15.	-1.4 to -3.1 MPa	-1.6 to -3.25 MPa	Low to Extremely Low	RE11.3.1 comprises a mix of brigalow with larger emergent coolabah. The coolabah's LWP values range from -1.6 to -3.25 MPa, in the Low to Extremely Low range, suggesting limited potential

Site	LWP Range (MPa) – EV1	LWP Range (MPa) – EV2	Water Availability (EV2)	Comments
				for groundwater usage. This is consistent with the coolabah's inferred shallow rooting system and its edaphic preference for clay soils. Brigalow sampled at these sites demonstrate Extremely Low water potentials (<1.95 MPa), which precludes groundwater usage, consistent with Brigalow's shallow root system concentrated in the upper portions of a heavy clay soil profile. The most applicable groundwater monitoring bore for these sites is MN-MB1-a, which reported a SWL of 10.58 mbgl and a groundwater salinity of 32 887 µS/cm in April 2025. While the SWL may be at the lower limits of tree rooting depth, the high salinity of the groundwater means that it provides an unsuitable source of moisture to support transpiration. Based on evidence from LWP sampling and information on groundwater depth and salinity, groundwater utilisation for these brigalow ecosystems is unlikely. This outcome is consistent between both the EV1 and EV2 sampling events. Soil moisture profiling and stable isotope analysis will provide further context.
RE11.4.9 and RE11.4.8 (Brigalow TEC) – *Eucalyptus cambageana / Acacia harpophylla / Brachychiton rupestris*				
Site CM_S4, CM_S5, CM_S6, CM_S7, CM_S9, CM_S10, CM_S11	-1.4 to -4.3MPa	-1.5 to -3.75 MPa	Low to Extremely Low	These habitats mix Dawson gum and brigalow, with both species demonstrating Low to Extremely Low moisture availability. Some extreme LWP values are reported for brigalow (-4 MPa in EV1), which indicates the species' tolerance of dry clay soils. Similar to Site CM_S8, a single narrow-leaf bottle tree at Site CM_S7 (*Brachychiton rupestris)* (T4) has an LWP value at -0.5 MPa, indicating Very High moisture availability, warranting additional scrutiny in the soil moisture and isotope analysis study components. The most relevant groundwater monitoring bores for these ecosystems are MN-MB4-b, MN-MB5-R, and MN-MB6-b, which have SWLs typically > 20 and salinities ranging from 21 000 to 51 900 µS/cm. Neither the considerable depth to groundwater nor the high salinity of groundwater for these monitoring bores render groundwater a likely source of moisture to support transpiration. No indication of groundwater utilisation at any of these assessment sites is given based on highly

Site	LWP Range (MPa) – EV1	LWP Range (MPa) – EV2	Water Availability (EV2)	Comments
				negative LWP values and hydro-chemically unsuitable groundwater sources. Additional scrutiny of the Very High LWP reported for a single narrow-leaf bottle tree is required.
RE11.7.2 – *Acacia shirleyi*				
CM_S13	-1.1 to -1.5 MPa	-1.0 to -1.9 MPa	Moderate to Very Low	As reported in the EV1 assessment, the lancewood habitat sampled at CM_S13 consistently has higher LWP values than brigalow sites. This is more likely associated with higher moisture availability in the supporting substrate rather than an indication of groundwater usage. The clay soils associated with brigalow have significantly more negative matric potentials than sandy or stony soils, which can host freely available moisture in pore spaces or fractures after a moisture recharge event.

6.2 Soil Auger Sampling

As per EV1, the EV2 assessment included the sampling of four soil auger holes, focusing specifically on habitats associated with the Brigalow TEC and at other locations where LWP values suggested increased moisture availability. This excludes auger sampling at Site CM_S10 which was abandoned in the EV1 assessment due extremely shallow bedrock. **Table 4** summarises auger location, target ecosystem, target geology, and depth, with auger logs representing the significant elements of the soil profile, including soil intervals and the presence of tree roots. Collection of soil samples occurred at each significant change in soil texture/moisture to measure SMP and stable isotope analysis. Soil moisture potential (SMP) was measured for each soil sample, and the results of these analyses were plotted directly on the auger logs. Appendix A shows the location of auger holes relative to sampled trees at each GDE assessment site. **Appendix C** provides a summary of SMP values.

6.2.1 RE11.3.1 (Auger CM14_AU1 and CM15_AU1)

Augers at sites CMS_14 and CMS_15 were placed into alluvial clays associated with the Brigalow TEC. In EV1, auger CM14_AU1 encountered 1.6 m of heavy alluvial clay (black soil) before being arrested in an indurated calcrete layer overlying hard grey clay / weathered sediment. Comparison between SMP profiles for EV1 and EV2 demonstrate similar intersections between SMP and LWP at the surface (-0.1 mbgl), although the soil profile had dried significantly below this depth in EV2, most likely due to soil moisture discharge because of transpiration (**Figure 11**). This possibly explains the slightly more negative LWP values reported in EV2 compared to EV1, However, data from both EV1 and EV2 suggest that LWP values can be accounted for by moisture in the shallow soil profile. Auger CM_S14 did not intersect groundwater in either EV1 or EV2, and the soil profile remained dry to full depth.

Table 4. The location, depth and target of shallow auger holes sampled during the assessment.

Auger Hole	Y	X	Ecosystem Sampled (RE)	Auger Target	Total Auger Depth EV1 (m)	Total Auger Depth EV2 (m)
CM3_AU1	-24.016563	148.69681	11.5.9	Base of sandy residual soils at their interface with either tight clays or weathered bedrock.	1.25	1.5
CM7_AU1	-24.042292	148.62364	11.4.9	Base of the clay soil profile, at its intersection with weathered basement rock.	2.80	2.75
CM10_AU1	-24.032721	148.71131	11.4.8	Weathered bedrock at the base of loamy surface sediments	0.7	NA
CM14_AU1	-24.058316	148.54832	11.3.1	Weathered bedrock at the base of the alluvial clay profile	1.6	1.55
CM15_AU1	-24.080332	148.57195	11.3.1	Weathered bedrock at the base of the alluvial clay profile	2.75	2.8

Compared to Site CM_S14, the auger at Site CM_S15 intersected a much deeper alluvial clay profile with a hardened grey-brown clay loam down to depths of 2.0 mbgl before passing into a more heterogeneous orange-brown mottled clay layer, with weathered sedimentary rock intersected at -2.8 mbgl. The soil profiles for EV1 (CM15_AU1) and EV2 (CM15_AU2) demonstrate similar moisture availability down the profile, with consistent intersections between LWP and SMP at the surface (<0.25 mbgl), at 1.5 mbgl and at the base of the auger, though more strongly for CM15_AU1 (**Figure 12**). Data for both EV1 and EV2 indicate that the range of LWP values measured at this site can be readily accounted for in the unsaturated portions of the soil profile. As per auger CM_S14, CM_S15 remained dry for its full depth.

6.2.2 RE11.4.9 (Auger CM7_AU1)

The location of Auger CM7_AU1 was an elevated clay plain that hosted a well-developed woodland of brigalow and Dawson gum (RE11.4.8). The initial auger in EV1 (CM7_AU1) intersected a relatively massive clay to clayey sand profile terminating in hard, dry clay with coarse gravel fragments at 2.8 mbgl. Intersection of coarse tree roots occurred at various depths, including 1.5 and 2.4 mbgl, and at the surface. The soil profile for EV2 was consistent with EV1, excluding the intersection of tree roots at 2.4 mbgl. For both EV1 and EV2, SMP values become progressively drier at depth in the profile, recording extremely negative SMP values as low as -5.7 MPa at 2.3 mbgl in EV2. The intersection of SMP and LWP values for both the EV1 and EV2 profiles occurred at shallow depths (<0.3 mbgl), indicating that vegetation was likely to be utilising moisture from shallow regions of the soil profile during both EV1 and EV2 assessments (**Figure 13**), possibly residual moisture recharge from pre-survey rainfall. The data indicates that unsaturated regions of the soil profile account for the moisture sources of brigalow during both the EV1 and EV2 assessments. The very high SMP reported at 0.1 mbgl in EV2 (-0.1 MPa) readily accounts for the Very High water availability recorded for the narrow-leaf bottle trees (CM7_5a) at this site in EV2 (-0.5 MPa).

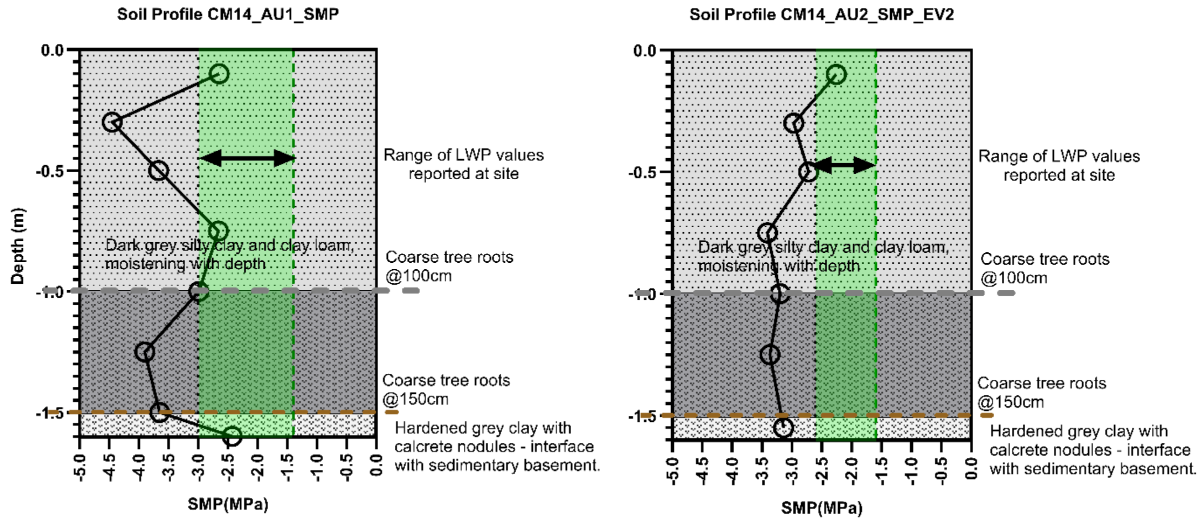

Figure 11. Auger profile for CM14_AU (1&2) showing the profile from EV1 on the left, and profile for EV2 on the right. The SMP data suggests that trees are deriving soil moisture exclusively from the upper soil profile in EV2.

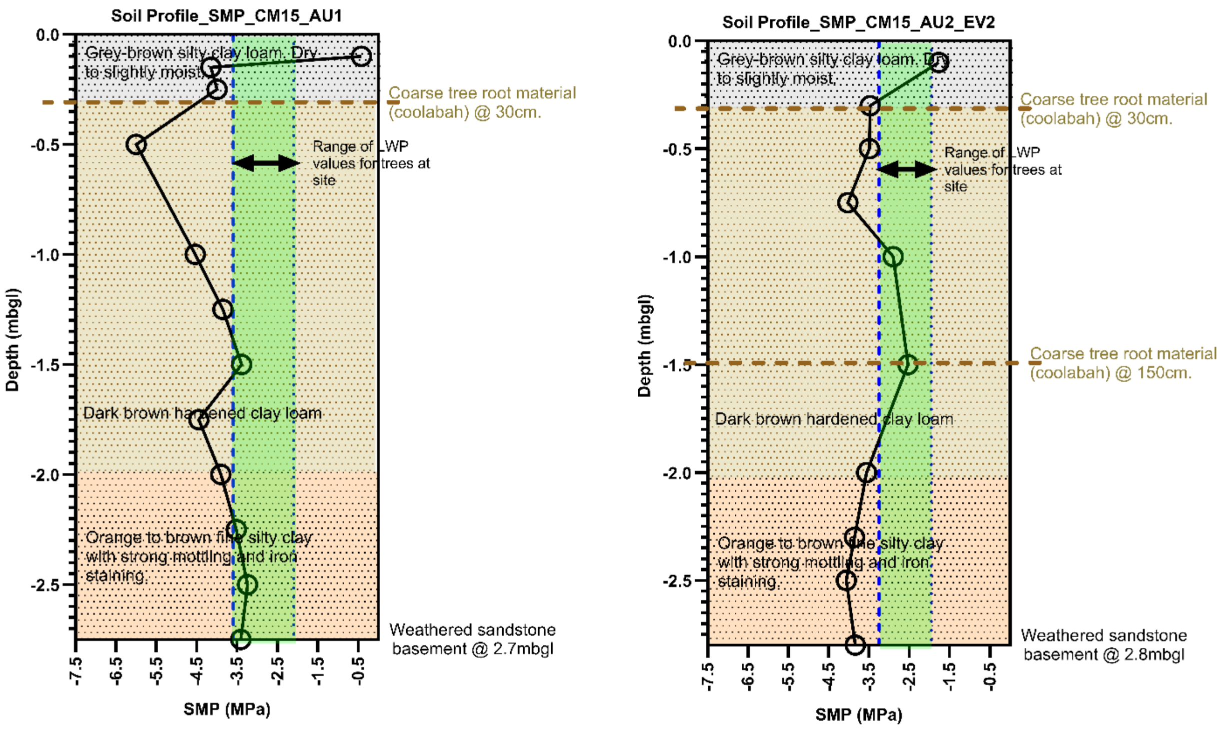

Figure 12. Auger profile for CM15_AU (1&2) showing the profile for EV1 on the left and EV2 on the right. Both soil profiles demonstrating an intersection of LWP and SMP values at the surface, and also at depths >1.5 mbgl. Moisture sources for vegetation can be readily accounted for in the shallow soil profile.

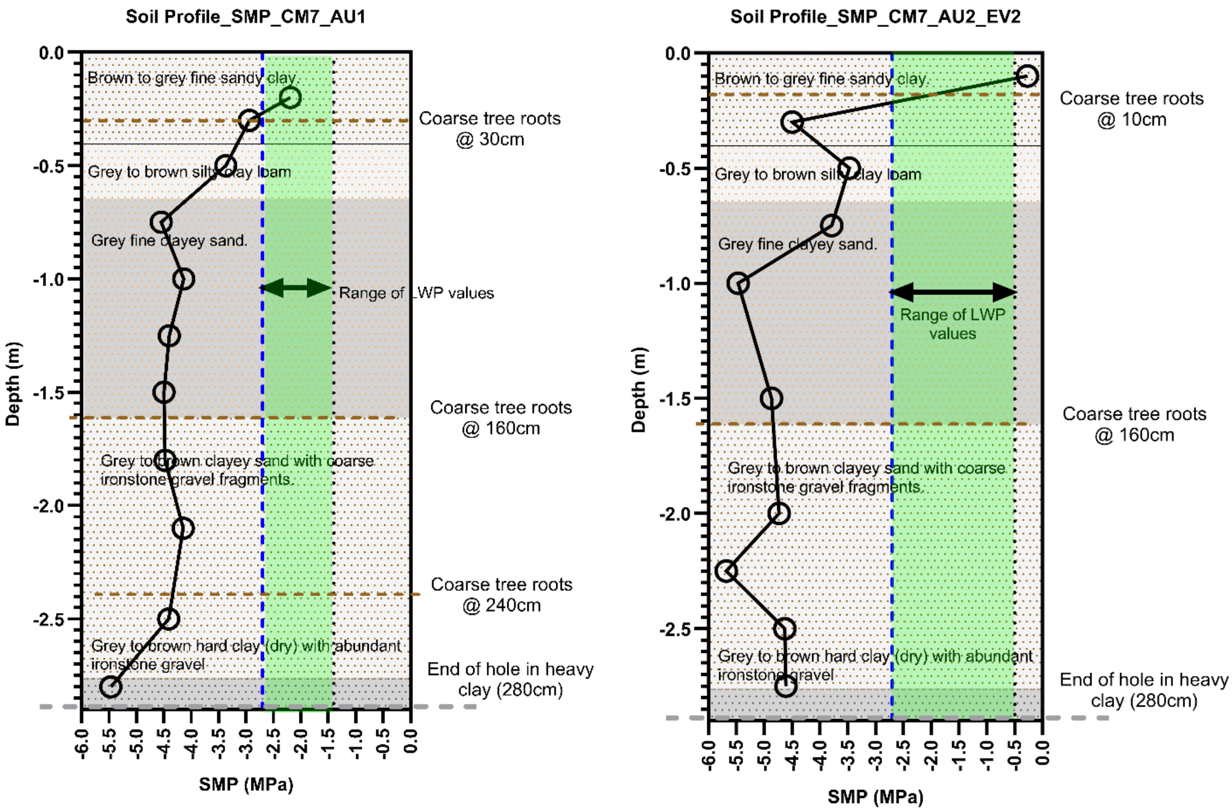

Figure 13. Auger profile for CM7_AU1 (EV1) on the left and CM7_AU2 (EV2) on the right. The profile demonstrates the intersection of LWP and SMP values at shallow depths in the soil profile for both assessments.

6.2.3 RE11.5.9 (Auger CM3_AU1)

Installation of auger CM3_AU1 occurred in sandy residual soils supporting a silver leaf ironbark dominant habitat (RE11.5.9). The purpose of the auger in the EV1 assessment was to determine if moisture availability in the shallow soil profile could explain the Moderate to High LWP values reported for trees at this site. A comparison between EV1 and EV2 profiles is shown in **Figure 14**, demonstrating that the soil profile had dried significantly between EV1 and EV2, consistent with the substantially more negative LWP values reported during the EV2 assessment. LWP values for the silver leaf ironbark and SMP intersect at a depth of approximately 0.75 mbgl in EV1, and near the surface during EV2 (-0.25 mbgl). For both the EV1 and EV2 assessments, soil profile data indicates that LWP values at the site during both EV1 and EV2 can be readily reconciled with moisture available in the shallow soil profile (see **Figure 14**).

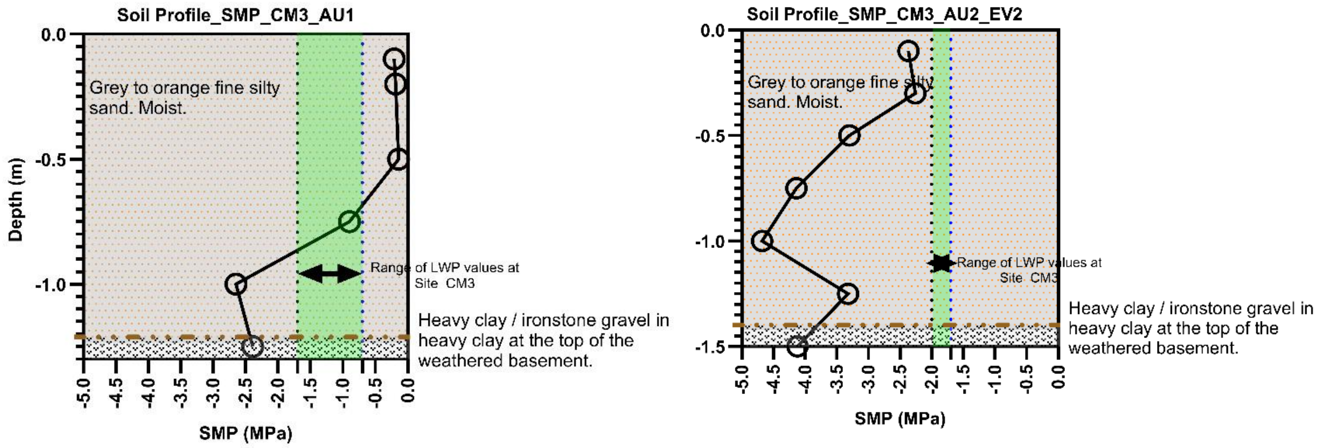

Figure 14. Auger profile for CM3_AU1 installed into sandy residual soils, demonstrating a shallow superficial cover of sand and intersection of LWP and SMP values at depths of approximately 0.75m in EV1 (left), and at depths <0.25 mbgl in EV2 (right).

6.3 Stable Isotope Sampling and Analyses

Section 6.3 presents an analysis of stable isotope data collected from soils, twig xylem, groundwater and surface water. The data is applied as an additional line of evidence to support biophysical measurements, which may assist data interpretation where any ambiguity in interpretation exists.

6.3.1 Stable isotope biplots and Lc-excess values

Figures 15 to **17** provide biplots representing stable isotope values ($\delta^{18}O$ and $\delta^{2}H$) for soil, twig xylem, groundwater, and surface water for sampling points within Brigalow TEC habitats RE11.3.1 (**Figure 15**), RE11.4.8 and 11.4.9 (**Figure 16**), and the eucalypt woodland habitats RE11.5.3 and 11.5.9 (**Figure 17**). **Figure 18** shows Lc-excess values represented as box and whisker plots for all sites and sample types. The analysis compares isotopic data from the EV1 and EV2 assessments, demonstrating the shift in isotopic compositions that have occurred between the two sampling events.

Notably, there are minor shifts in the isotopic composition of groundwater sampled from the two monitoring bores sampled (MN-MB1-a & MN-MB-6b) between the EV1 and EV2 assessments. The minor isotopic shifts are not consequential regarding interpretation of the data, and the lack of significant isotopic variation in the two monitoring bores subject to repeat sampling suggests only limited influence of seasonal rainfall on the isotopic composition of groundwater in both the Tertiary sediments and coal seams. For all three vegetation groupings, the following trends are notable:

1. The isotopic values of the soil samples for EV1 and EV2 demonstrate a broad scatter, though consistent overlap, which indicates only limited change in the isotopic composition of soil moisture between EV1 and EV2.
2. Isotopic compositions of the twig xylem consistently overlap with the scatter of soil isotopic values for all three vegetation groupings, suggesting that soil moisture supports transpiration for woodland habitats broadly across the Project area.

3. The cluster of isotopic values formed by groundwater is generally lighter (depleted in ^{18}O) than clusters formed by xylem and soils with only marginal overlap between xylem, soil, and groundwater values.
4. There is a weak overlap between the isotopic composition of groundwater samples with twig xylem in RE11.4.8_11.4.9 (**Figure 16**) and RE11.5.3_11.5.9 (**Figure 17**). Based on extremely negative LWP values recorded in these habitats for both EV1 and EV2 (see **Section 6.1**), this more likely reflects overlap in the isotopic composition of groundwater and soil moisture rather than any direct evidence of vegetation groundwater usage. The specimen of narrow-leaf bottle tree (CM8_T4) presents a xylem stable isotope composition that is consistent with other trees at the site.

With consideration given to highly negative LWP values recorded for all habitats, the lack of any consistent overlap between twig xylem and groundwater isotopic values suggests that transpiration is supported by soil moisture from the unsaturated zone across habitats broadly throughout the Project area.

The lc-excess data (Figure 18) indicate the evolution of groundwater sources away from the LMWL, suggesting that evaporative processes have acted on surface water prior to its infiltration. For RE11.5.3/11.5.9, lc-excess values have shifted closer to meteoric values between EV1 and EV2, suggesting rapid infiltration of rainfall into the sandy soil profile prior to sampling. However, for the brigalow dominant ecosystems RE11.4.8/11.4.9, lc-excess values of xylem samples are more negative in the EV2 than EV1 and have a consistent, substantial overlap with lc-excess values of soil samples. The lc-excess values of xylem for RE11.3.1 are significantly more negative than the associated soil samples, with only a weak overlap between the datasets, indicating the influence of surface water flows on vegetation moisture sources at these assessment sites. Overall, the variability of the xylem and soil moisture lc-excess indicates that deep-rooted plants react to variations in the isotopic compositions of soil moisture. At the same time, groundwater maintains relatively stable lc-excess values across the seasons. This substantial variation in twig xylem lc-excess values between sampling events clearly indicates the influence of soil moisture on vegetation moisture sources, rather than the more consistent influence of groundwater.

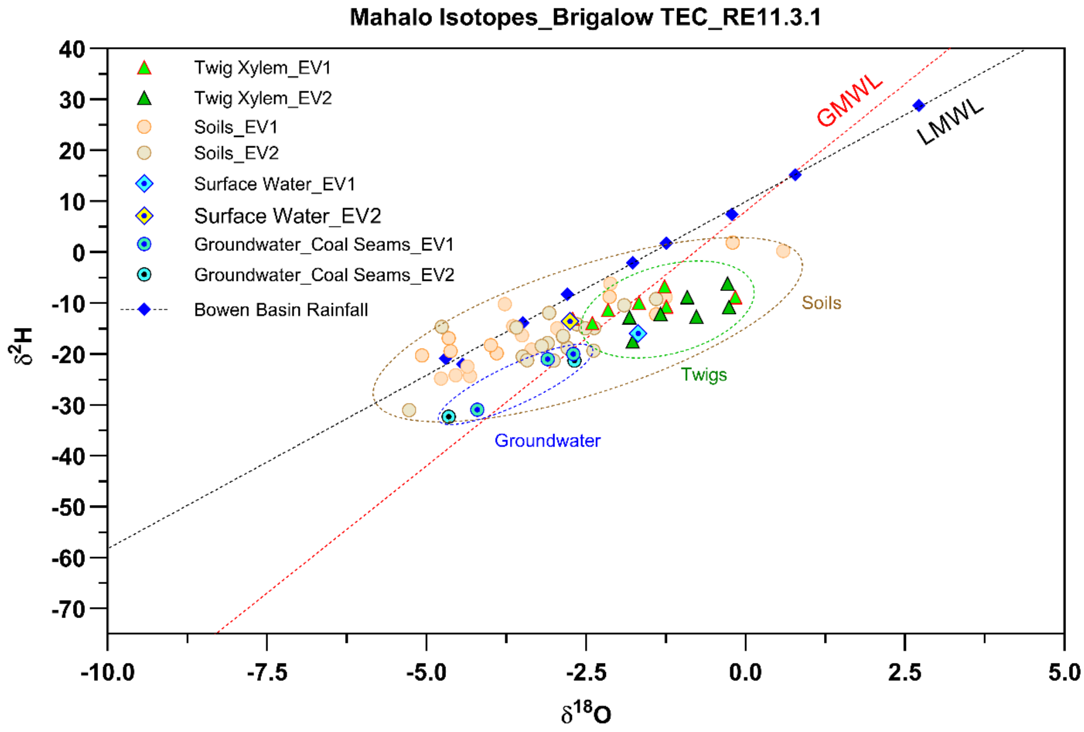

Figure 15. Stable isotope scatter for sites within RE11.3.1 (CM14 and CM15) for EV1 and EV2 showing overlap between isotopic compositions of xylem and soil samples for both sampling events, and clear lack of overlap between xylem and groundwater samples. The LMWL is indicated by the black dashed line with the GMWL indicated by the red.

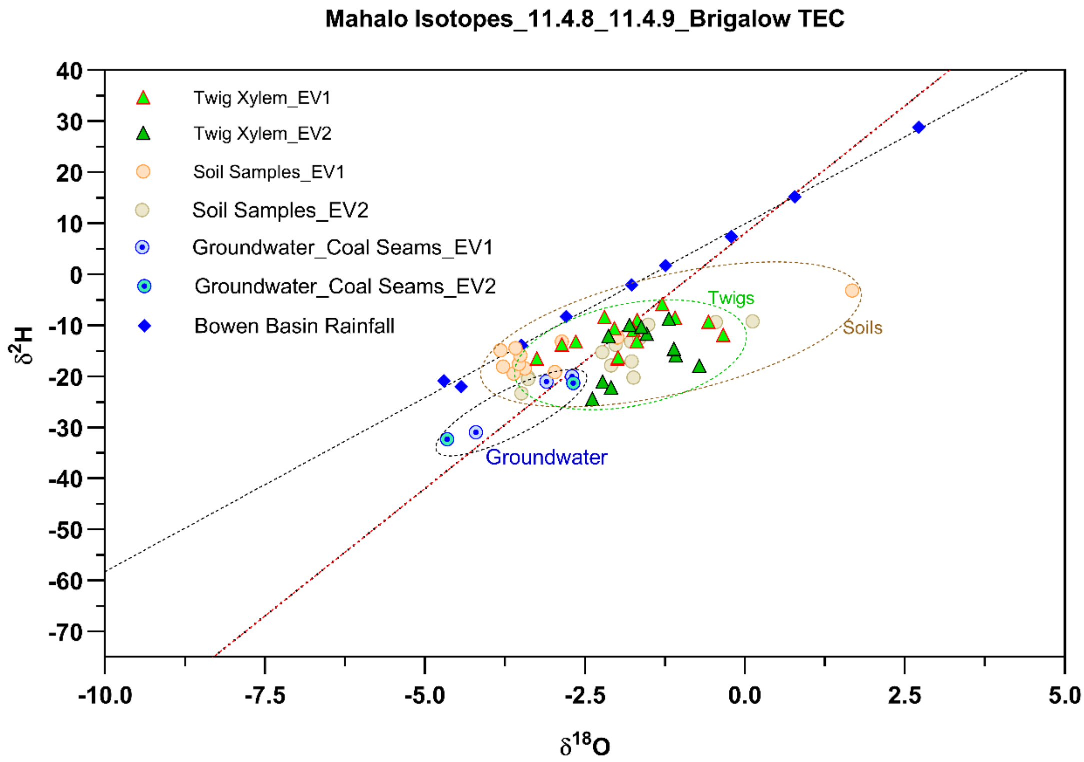

Figure 16. Stable isotope scatter for sites within RE11.4.8/11.4.9 for both EV1 and EV2, showing overlap between isotopic compositions of xylem and soil samples, and limited overlap between xylem and groundwater samples.

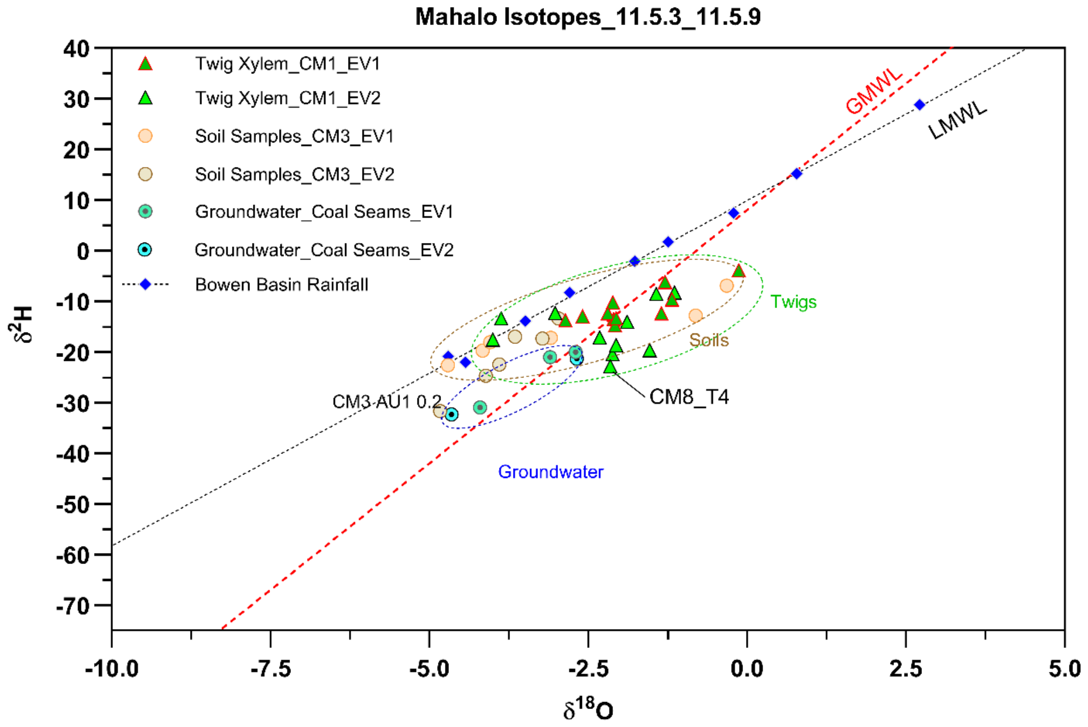

Figure 17. Stable isotope scatter for sites associated with REs 11.5.3 and 11.5.9 showing overlap between isotopic compositions of xylem and soil samples for EV1 and EV2. Vegetation use of soil moisture is the most likely reason for the weak overlap between xylem and groundwater isotopic values, based on the highly negative LWP values reported for these sites.

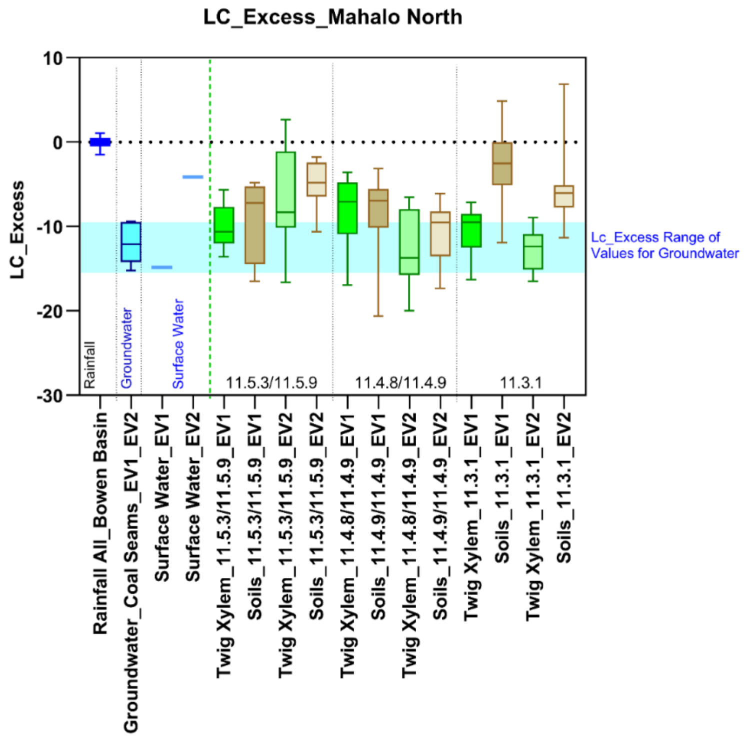

Figure 18. Lc-excess values for all sites comparing the results for EV1 and EV2. The considerable variation in lc-excess values for soils and xylem between sampling events suggests that deep-rooted vegetation is reactive to changes in soil moisture isotopic composition, rather than supported by an isotopically consistent groundwater source.

6.3.2 Downhole δ18O soil profiles

The data below reconciles downhole δ18O values for all auger holes with the range of values reported for twig xylem. Reconciliation with biophysical data from **Section 6.3.2** and **6.3.3** is also provided where required.

RE11.3.1 (CM14_AU1 & CM15_AU1): Figure 19 compares the downhole δ18O values for augers CM14_AU1 (EV1) and CM14_AU2 (EV2). The data indicates overlap between soil and twig xylem values in the upper 30cm of the soil profile and again at 1.25 mbgl during EV1. For CM14_AU2, a minor disjunct has developed between soil moisture and xylem δ18O values, which suggesting fractionation of soil moisture isotopes at the soil/root interface Tetzlaff et al., 2021), indicative of isotopic processes in the unsaturated regions of the soil profile. **Figure 20** compares the downhole δ18O values for augers CM15_AU1 (EV1) and CM15_AU2 (EV2), suggesting overlap between soil and twig xylem values in the upper 30cm of the soil profile, plus a weak overlap between these values at 2.25 mbgl. Consistent with the results of the SMP sampling (**Section 6.2**), the isotopic profiles suggest vegetation moisture sources are being derived from unsaturated regions of the soil profile.

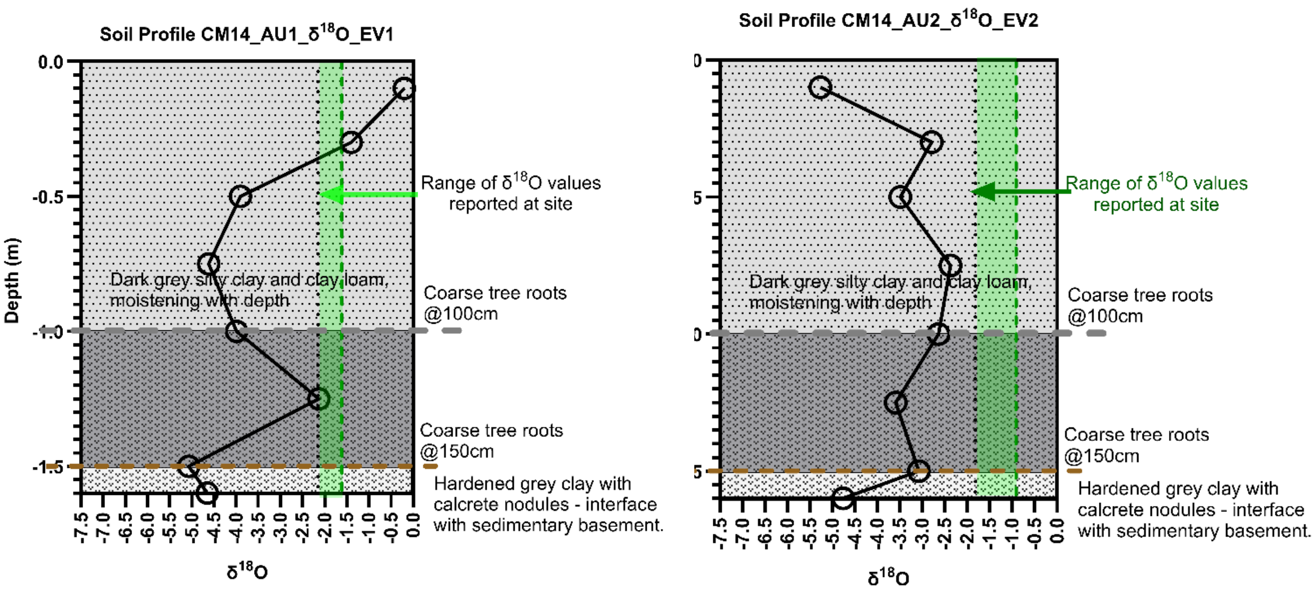

Figure 19. Downhole δ18O values for augers CM14_AU1 (EV1 on the left) and CM14_AU2 (EV2 on the right) showing the intersection of isotopic values for twig xylem and soil moisture in the upper 0.3m of the soil profile for EV1. This is minor decoupling between soil and xylem isotopic values in EV2, which might indicate the effects of isotopic fractionation of moisture sources at the root/soil interface.

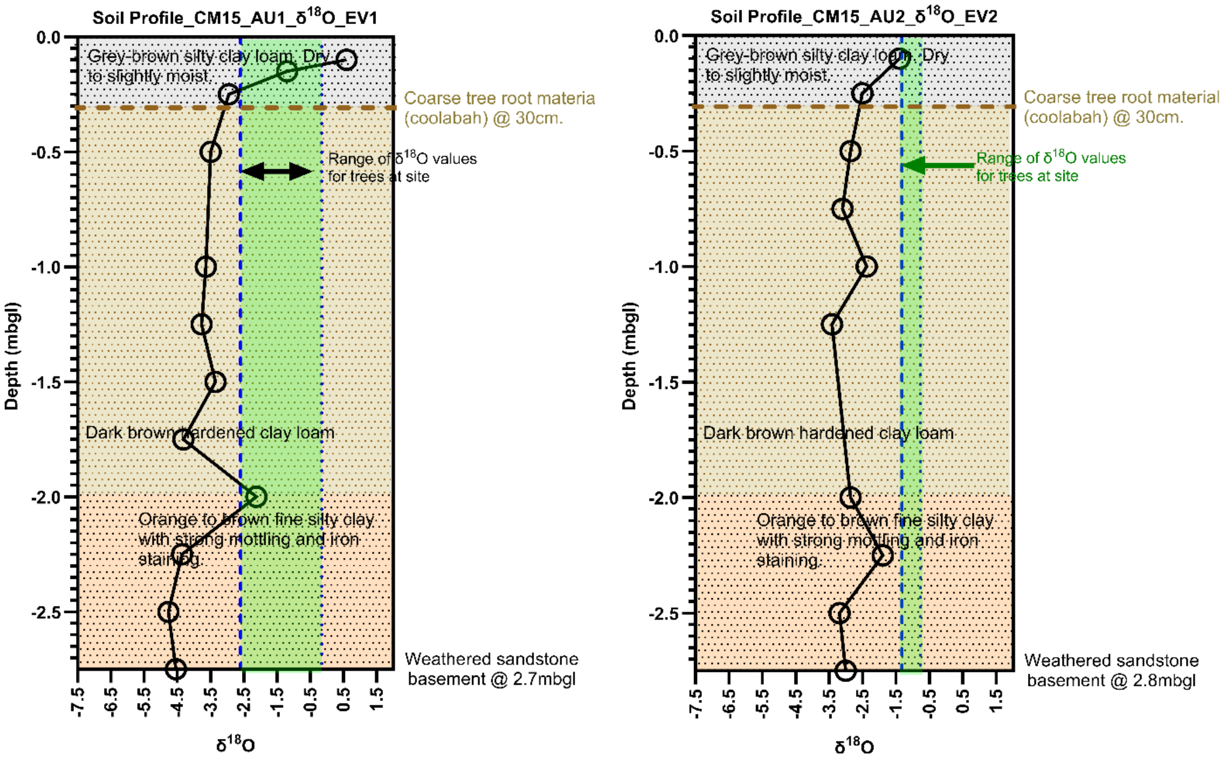

Figure 20. Comparison between EV1 and EV2 auger profiles for site CMS_15, showing overlap between xylem and soil δ^{18}O values at the surface (0.3 mbgl), and also at a depth of approximately 2.25 mbgl.

E11.4.8 & 1 1.4.9 (CM7_AU1): Figure 21 compares the EV1 and EV2 downhole δ18O values for augers CM7_AU1 and CM7_AU2 located in RE11.4.9 at Site CM7. While there are some isotopic variations between the monitoring events, both profiles demonstrate an overlap between soil and xylem δ18O values within the shallow profile. In EV1, this isotopic overlap is restricted to near the soil surface and at 1.5 mbgl, while the overlap is considerably more extensive and better defined in the EV2 profile. Both assessment events support vegetation use of soil moisture from unsaturated regions of the soil profile.

RE11.5.9 (CM3_AU1): Figure 22 illustrates the downhole δ18O values for shallow auger CM3_AU1 within RE11.5.9 during EV1, and a repeat of this auger in EV2 for CM3_AU2. The data illustrates the isotopic overlap between twig xylem and soil moisture at shallow depths (<0.5 mbgl) in EV1, and with a substantial overlap below 0.3 m to the base of the auger at 1.5 mbgl for EV2. For both EV1 and EV2, the data indicates that shallow soil moisture has capacity to account for the moisture sources of woodland vegetation, consistent with other lines of evidence including SMP.

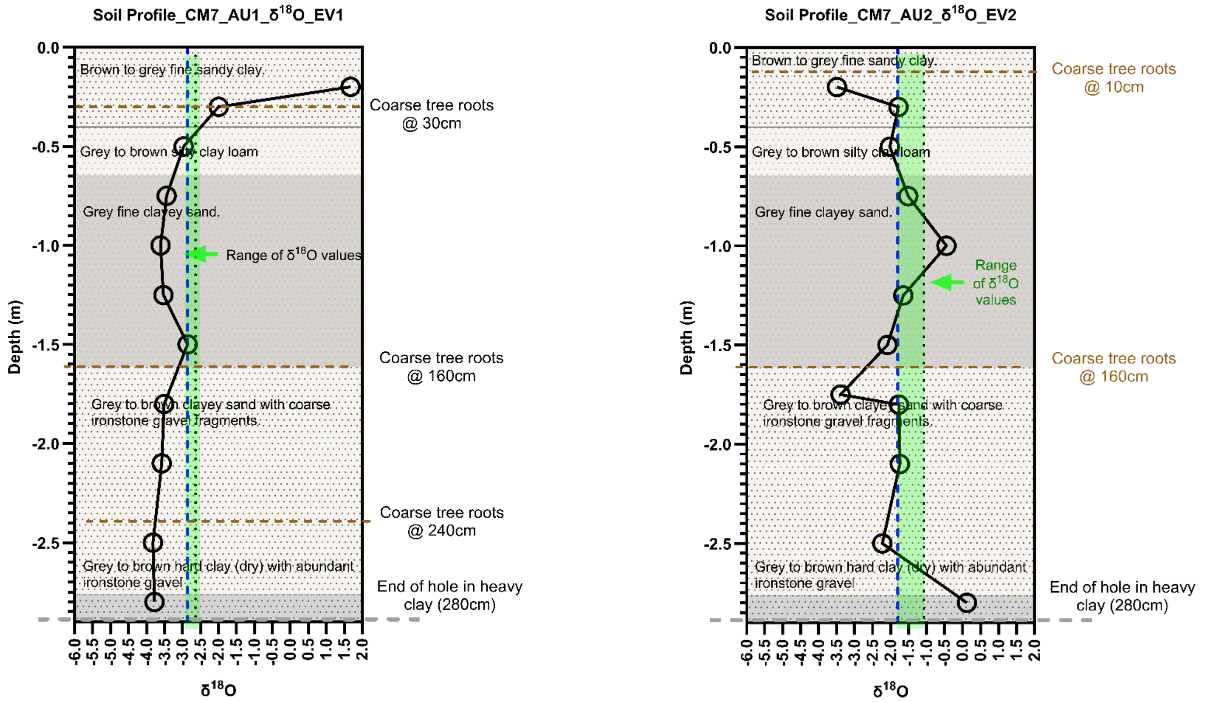

Figure 21. Downhole δ18O values for auger CM7_AU1 (EV1) and CM7_AU2 (EV2) in RE11.4.9, showing the intersection between twig xylem and soil moisture in the upper 0.3m of the soil profile and at 1.5 mbgl in EV1, and the broad intersection in of these values in EV2.

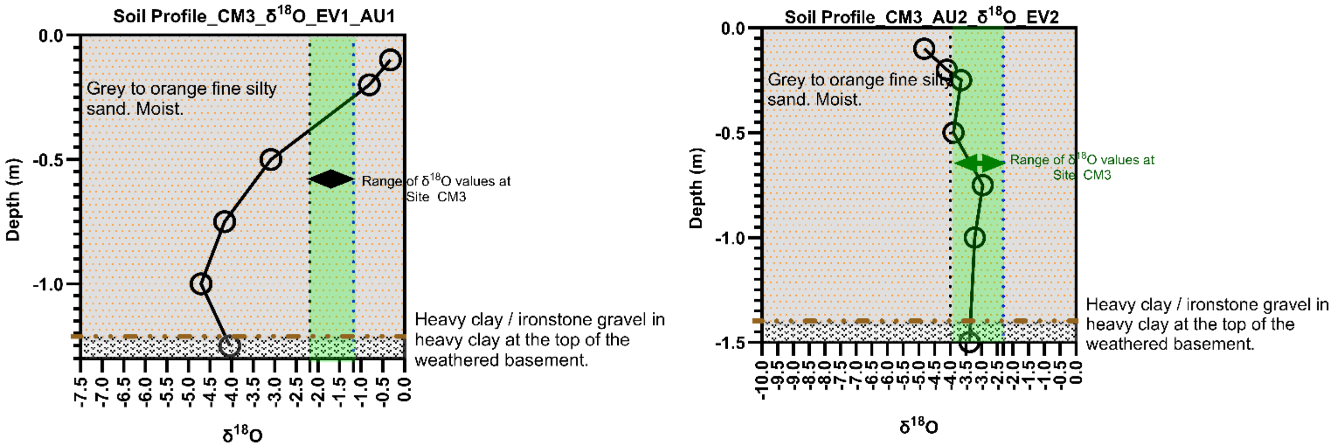

Figure 22. Downhole δ18O values for auger CM3_AU1 (RE11.5.9) showing the intersection of isotopic values for twig xylem and soil moisture at shallow depths, <0.5 m from the soil surface.

7.0 Discussion and Conceptualisation of Tree Moisture Sources

Two repeat GDE assessments have been completed for the Mahalo North project on PLA 1128. The two surveys draw the same conclusions, with only subtle variations in the results of biophysical and hydrochemical assessments. The overriding conclusion is of these two assessments, completed under similar climatic conditions, is that soil moisture held in unsaturated shallow regions of the soil profile predominantly supports transpiration by deep-rooted woody vegetation across the Project area. The significant factors indicating that the reliance on groundwater by woody vegetation is insignificant include:

- LWP values for all trees sampled from a range of habitats, including both brigalow and eucalypt woodlands, are consistently strongly negative for both the EV1 and EV2 assessments, suggesting that woody vegetation is either reliant on soil moisture from unsaturated portions of the soil profile that is held tightly in a clay matrix, or trees are using a highly saline groundwater source.
- The SMP values of the four deeper augers sampled during both EV1 and EV2 demonstrate varying degrees and positions of overlap with site LWP values. This overlap suggests that moisture in unsaturated regions of the soil profile alone, has capacity to account for the moisture status of woody vegetation.
- Analysis of stable isotope trends confirm that the unsaturated zone is the dominant moisture source supporting transpiration across PLA1128. There is limited overlap between the isotopic composition of sampled xylem moisture and groundwater samples, while a consistent isotopic overlap exists between twigs and soils for both the EV1 and EV2 assessments. Downhole δ18O profiles also support a source of moisture from shallow regions in the soil profile.
- Groundwater may conceptually occur within the root zone of riparian vegetation on Humbolt Creek, in the vicinity of MN-MB1a where groundwater monitoring indicates SWLs of <10 mbgl. The highly saline groundwater within this monitoring bore (up to 32 887 µS/cm) would however be an unsuitable source of moisture to support transpiration.

In EV1, CM_S3 associated with RE11.5.9, was the only site that presented LWP values that might indicate potential for groundwater usage, being as high as -0.7MPa in silver-leaf ironbark. For EV2, tree water availability had decreased substantially to an average of -1.8 MPa, being more consistent with LWP values reported for other habitats in the Project area. For both EV1 and EV2 however, LWP values could be readily accounted for, and was consistent with soil moisture in shallow unsaturated regions of the soil profile. Other eucalypts sampled across the Project site, including coolabah (within RE11.3.1), poplar box (within RE11.5.3), and Dawson gum (within RE11.4.9) demonstrated LWP values that were consistently close to or below standard wilting point (-1.5 MPa) during EV1 and EV2. In the context of eucalypts, this does not mean that the trees are necessarily stressed or in severe moisture deficit, though it does indicate that their moisture sources are likely to be tightly bound to soils in unsaturated regions of the soil profile, rather than free draining. Eucalypt species that are co-occurring with brigalow such as coolabah and Dawson gum are likely to be similarly adapted to moisture constrained clay soils.

The shallow root system of brigalow is evident from auger sampling, where tree moisture availability correlated with shallow regions in the soil profile, and 2.4 mbgl was the deepest brigalow rooting depth recorded. Strong drying of the soil profile with increasing depth is evident at site CM_S7 (in both auger CM7_AU1 and CM7_AU2), below the recorded rooting depth of brigalow. The extreme dryness of the basement clays (-5.5MPa @2.8 mbgl for CM7_AU1) would impede the deeper root penetration required for brigalow trees to access groundwater.

The two specimens of narrow-leaf bottle tree (*Brachychiton rupestris*) sampled within or adjacent to brigalow habitats at CM_S7 and CM_S8 demonstrated extremely negative LWP values in EV1 (-2.75 and -2.2MPa). However, LWP values for these trees were Very High in EV2 (-0.5 MPa). Dry vine forest species can maintain drought tolerance through several physical and physiological adaptions, including leaf fall (deciduousness) at progressively lower LWP, lower leaf surface area (LSA) reflecting a greater degree of sclerophylly (Eamus, 1999; Lamont et al., 2002), and stomata closure at low LWP (Smith et al., 1997). The shallow spreading root mass of narrow-leaf bottle tree likely reflects an opportunistic water use strategy which is reactive to rainfall. The Very High LWP values reported for narrow-leaf bottle tree in the EV2 assessment likely reflects the efficient uptake of recent rainfall. SMP from CM7_AU2 (EV2) indicates Very High moisture availability in the upper 30 cm of the soil profile, consistent with reported LWP values for the narrow-leaf bottle tree. Therefore, there is no indication that the Very High LWP values reported are an indication of groundwater reliance for this species.

8.0 Conclusions

The major conclusions drawn from this assessment are:

- Brigalow predominantly draws moisture from the shallow soil profile down to depths of 2.4 mbgl, where extremely dry and hard clays arrest deeper penetration, which is consistent with previous studies on Brigalow, which suggest a shallow rooting system.
- There is no evidence from LWP measurement recorded in brigalow that trees rely on permanent or seasonal groundwater sources, supported by the observed susceptibility of the species to droughting. SMP measurements confirm that unsaturated regions of the soil profile have capacity to support the moisture availability measured in leaves.
- Stable isotope analysis also supports brigalow deriving moisture from shallow regions in the unsaturated soil profile, with substantial isotopic overlap between twig xylem and soils and limited overlap between twig xylem and groundwater sources.
- Eucalypts across the Project site are mostly shallow-rooted box species that rely on moisture from the shallow soil profile. Some species, such as Dawson gum, have a strong affinity with brigalow, suggesting that they derive moisture from similar shallow regions of the soil profile. Based on LWP values, there is no indication of any substantial groundwater utilisations for any eucalypt species on the Project site. Stable isotope analysis supports a lack evidence for groundwater usage, demonstrating a strong affinity between soil and twig xylem moisture sources and limited interaction between twig xylem moisture and groundwater sources.

- While narrow-leaf bottle tree reported Very High LWP values were in the EV2 assessment, this likely reflects efficient harvesting of rainfall that has infiltrated into the shallow soil profile, rather than use of groundwater. Auger sampling supports this interpretation, identifying very high moisture availability in the shallow soil profile adjacent to these trees.

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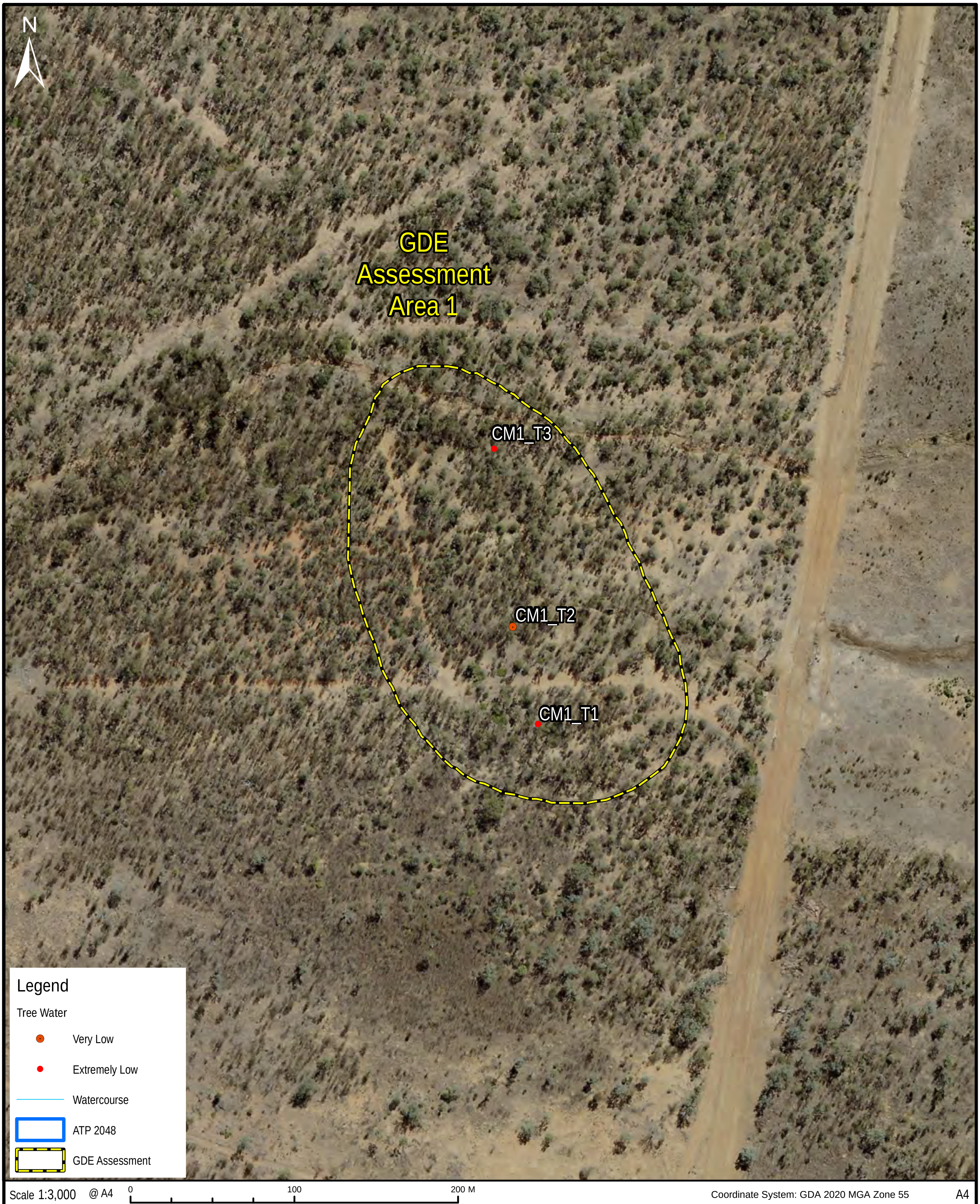
10. Appendix

Appendix A. Tree Structural Measurements

Waypont Number	Latitude	Longitude	Tree Sample Point	Species	DBH	Height	LWP_2024	LWP_2025	Tree Water Availability 2025
CM1_T1	-24.018838	148.643623	CM1_T1	Eucalyptus populnea	420	17	-1.7	-2.35	Extremely Low
CM1_T2	-24.018305	148.643464	CM1_T2	Eucalyptus populnea	350	13	-1.7	-1.95	Very Low
CM1_T3	-24.017323	148.643341	CM1_T3	Eucalyptus populnea	400	18	-2.1	-2.55	Extremely Low
CM10_T1	-24.032384	148.711343	CM10_T1	Eucalyptus cambageana	500	17	-1.7	-2.1	Very Low
CM10_T2	-24.032745	148.711341	CM10_T2	Eucalyptus cambageana	700	15	-1.8	-1.9	Very Low
CM10_T3	-24.033027	148.711282	CM10_T3	Eucalyptus cambageana	900	20	-1.6	-2.15	Very Low
CM10_T4	-24.032856	148.711067	CM10_T4	Eucalyptus cambageana	750	20	-1.5	-1.9	Very Low
CM11_T1	-24.04491	148.708557	CM11_T1	Eucalyptus cambageana	700	20	-2.1	-2	Very Low
CM11_T2	-24.045026	148.708571	CM11_T2	Eucalyptus cambageana	600	18	-1.9	-1.5	Low
CM11_T3	-24.045228	148.70882	CM11_T3	Acacia harpophylla	150	7	-2	-1.9	Very Low
CM11_T4	-24.045285	148.708892	CM11_T4	Eucalyptus cambageana	450	18	-2.5	-1.55	Low
CM13_T1	-24.038573	148.681972	CM13_T1	*Acacia shirleyi*	20	12	-1.4	-1.5	Low
CM13_T2	-24.038188	148.681808	CM13_T2	*Acacia shirleyi*	15	11	-1.2	-1.9	Very Low
CM13_T3	-24.038338	148.682127	CM13_T3	*Acacia shirleyi*	25	11	-1.55	-1	Moderate
CM14_T1	-24.057949	148.54885	CM14_T1	Eucalyptus coolabah	300	10	-1.7	-2.6	Extremely Low
CM14_T2	-24.058007	148.548721	CM14_T2	Eucalyptus coolabah	400	12	-1.9	-2.4	Extremely Low
CM14_T3	-24.05822	148.548323	CM14_T3	Eucalyptus coolabah	500	16	-1.4	-1.6	Low
CM14_T4	-24.058323	148.548449	CM14_T4	Acacia harpophylla	250	12	-3	-2.7	Extremely Low
CM15_T1	-24.079441	148.570755	CM15_T1	Eucalyptus coolabah	400	15	-2.1	-2.5	Extremely Low
CM15_T2	-24.079322	148.57047	CM15_T2	Acacia harpophylla	200	9	-3.6	-1.95	Very Low
CM15_T3	-24.079393	148.57061	CM15_T3	Eucalyptus coolabah	450	14	-2.2	-3.25	Extremely Low
CM15_T4	-24.080423	148.571987	CM15_T4	Eucalyptus coolabah	1000	19	-2.05	-1.5	Low
CM15_T5	-24.080511	148.572214	CM15_T5	Acacia harpophylla	300	9	-2.1	-2	Very Low
CM3_T1	-24.016664	148.696769	CM3_T1	Eucalyptus melanophloia	300	12	-0.7	-1.7	Low
CM3_T2	-24.016419	148.696847	CM3_T2	Eucalyptus melanophloia	250	11	-1.7	-1.9	Very Low
CM3_T3	-24.01616	148.696715	CM3_T3	Eucalyptus melanophloia	430	16	-1	-2	Very Low

Waypont Number	Latitude	Longitude	Tree Sample Point	Species	DBH	Height	LWP_2024	LWP_2025	Tree Water Availability 2025
CM4_T1	-24.021842	148.62904	CM4_T1	Acacia harpophylla	270	12	-1.5	-2.2	Extremely Low
CM4_T2	-24.021593	148.629148	CM4_T2	Eucalyptus cambageana	500	13	-1.5	-2.8	Extremely Low
CM4_T3	-24.0206	148.629297	CM4_T3	Acacia harpophylla	250	11	-2	-3	Extremely Low
CM4_T4	-24.020091	148.62949	CM4_T4	Acacia harpophylla	250	12	-2.15	-3.3	Extremely Low
CM5_T1	-24.016403	148.618229	CM5_T1	Acacia harpophylla	350	14	-3.8	-3.05	Extremely Low
CM5_T2	-24.016308	148.61839	CM5_T2	Acacia harpophylla	300	14	-2.9	-2.1	Very Low
CM5_T3	-24.015846	148.618471	CM5_T3	Acacia harpophylla	250	12	-3	-2.65	Extremely Low
CM6_T1	-24.016508	148.621291	CM6_T1	Eucalyptus cambageana	400	18	-2.2	-2.95	Extremely Low
CM6_T2	-24.016401	148.621371	CM6_T2	Acacia harpophylla	300	12	-3.65	-3.6	Extremely Low
CM6_T3	-24.016179	148.621312	CM6_T3	Acacia harpophylla	300	15	-4.35	-3.7	Extremely Low
CM7_T1	-24.042181	148.623753	CM7_T1	Eucalyptus cambageana	650	14	-1.4	-1.75	Very Low
CM7_T2	-24.042299	148.623593	CM7_T2	Acacia harpophylla	350	13	-2	-2.5	Extremely Low
CM7_T3	-24.042363	148.623422	CM7_T3	Acacia harpophylla	280	13	-2.3	-2.7	Extremely Low
CM7_T4	-24.042224	148.623279	CM7_T4	Acacia harpophylla	250	12	-1.9	-1.9	Very Low
CM7_T5	-24.042224	148.623164	CM7_T5	Brachychiton rupestris	350	6	NA	-0.5	Very High
CM8_T1	-24.043669	148.620606	CM8_T1	Eucalyptus populnea	350	13	-1.2	-1.55	Low
CM8_T2	-24.04339	148.620468	CM8_T2	Eucalyptus populnea	300	9	-1.1	-1.45	Low
CM8_T3	-24.042971	148.620481	CM8_T3	Acacia harpophylla	250	11	-2	-3.5	Extremely Low
CM8_T4	-24.042618	148.620347	CM8_T4	Brachychiton rupestris	1200	16	-2.2	-0.5	Very High
CM9_T1	-24.050642	148.705551	CM9_T1	Eucalyptus cambageana	500	15	-2.5	-1.6	Low
CM9_T2	-24.050585	148.705799	CM9_T2	Eucalyptus cambageana	450	15	-2	-2.1	Very Low
CM9_T3	-24.050561	148.705944	CM9_T3	Eucalyptus cambageana	700	15	-1.7	-2.05	Very Low
CM9_T4	-24.050275	148.70591	CM9_T4	Acacia harpophylla	200	7	-2.6	-2.6	Extremely Low
CM12_T1	-24.010598	148.609897	CM12_T1	Eucalyptus populnea	550	18	-1.9	-1.9	Very Low
CM12_T2	-24.010624	148.610086	CM12_T2	Eucalyptus populnea	600	17	-1.7	-1.8	Very Low
CM12_T3	-24.01061	148.61044	CM12_T3	Eucalyptus populnea	500	17	-2.1	-1.5	Low
CM12_T4	-24.011015	148.610554	CM12_T4	Eucalyptus populnea	650	19	-2	-1.95	Very Low

Appendix B. Sampling locations and Moisture Availability



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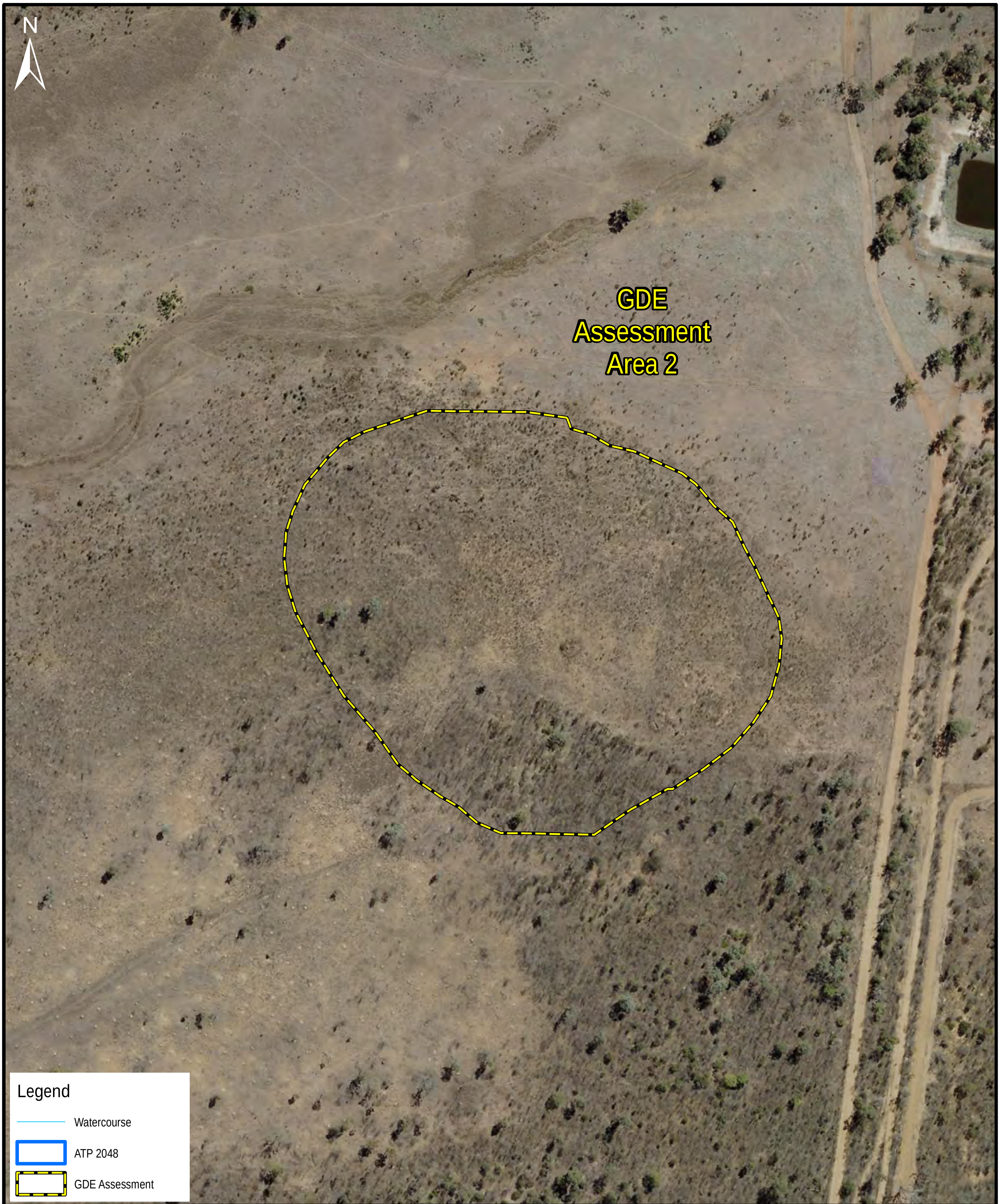
Appendix A1. Sampling detail at GDE Assessment Area 1

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Client: Comet Ridge Mahalo Pty Ltd:
Project. Mahalo North

Drawn By DG Checked DS Date 19/10/2025

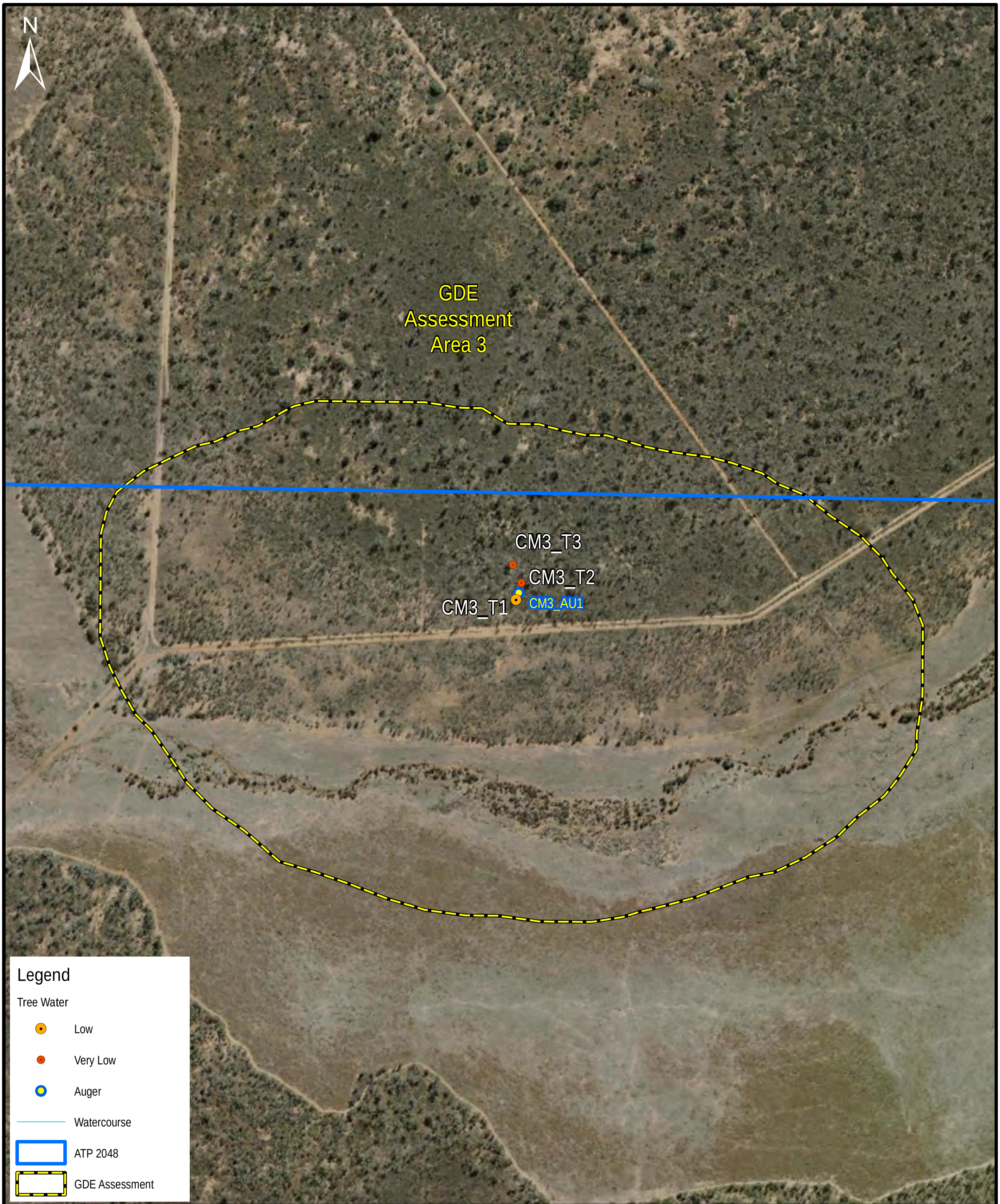


Appendix A2. Sampling detail at GDE Assessment Area 2

Client: Comet Ridge Mahalo North Pty Ltd
Project Mahalo North

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Drawn By DG Checked DS Date 19/10/2025



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Scale 1:8,000 @ A4 0 100 200 M

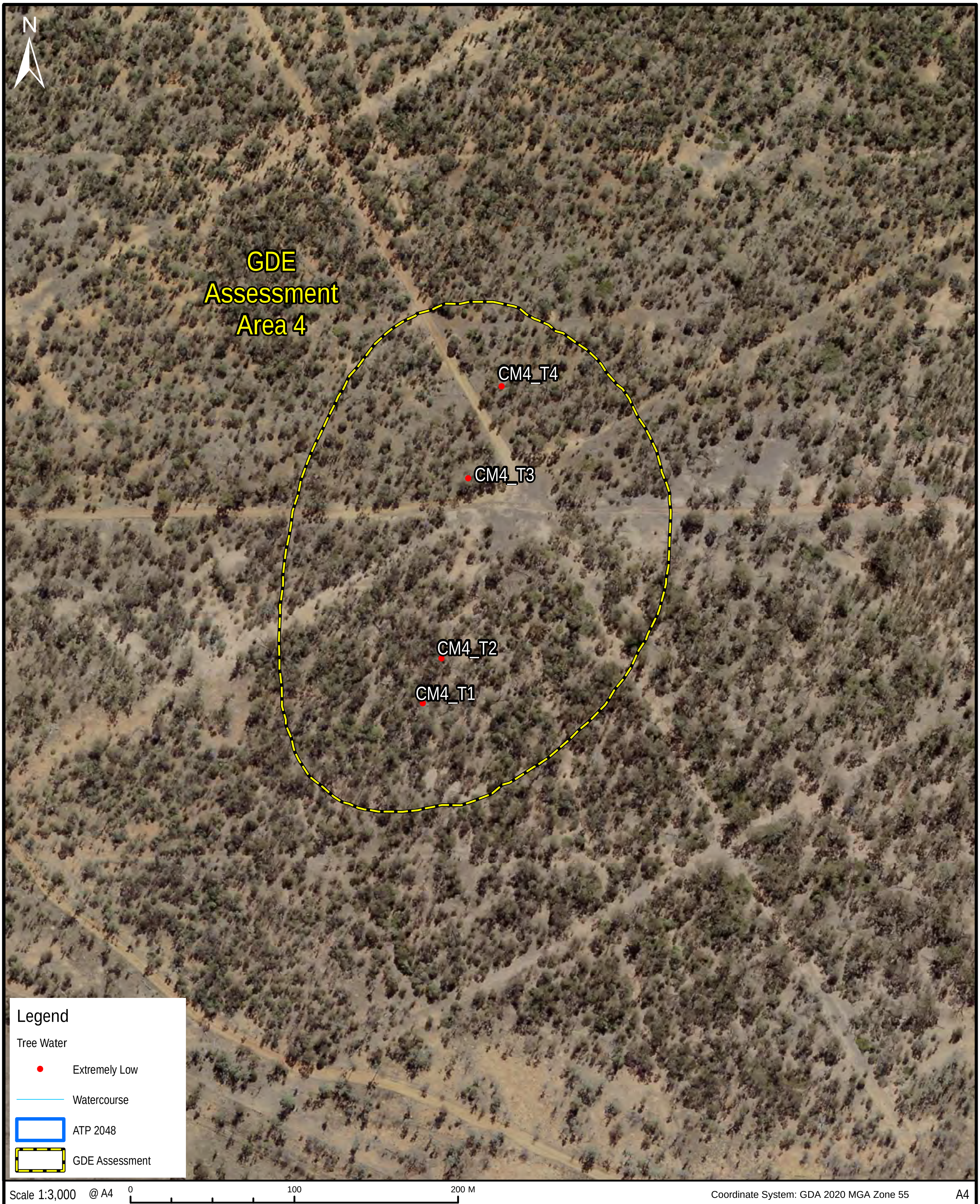
Coordinate System: GDA 2020 MGA Zone 55 A4

Appendix A3. Sampling detail at GDE Assessment Area 3

Client: Comet Ridge Mahalo North Pty Ltd
Project: Mahalo North

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Drawn By DG Checked DS Date 19/10/2025



Appendix A4. Sampling detail at GDE Assessment Area 4

Client: Comet Ridge Mahalo North Pty Ltd
Project. Mahalo North

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Drawn By DG Checked DS Date 19/10/2025

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Appendix A5. Sampling detail at GDE Assessment Area 5

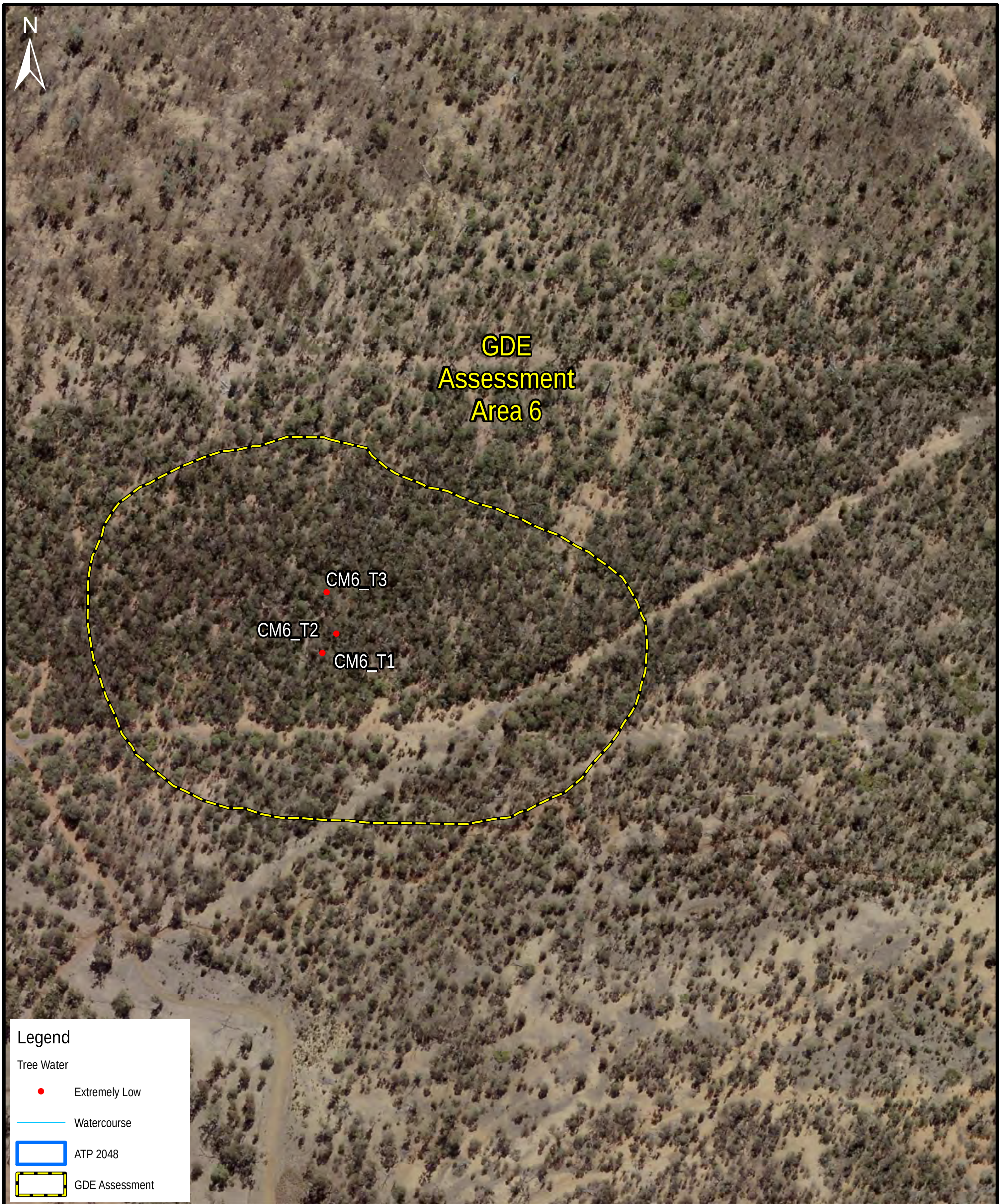
WATER MARK ECO

Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Client: Comet Ridge Mahalo North Pty Ltd:

Project. Mahalo North

Drawn By DG Checked DS Date 19/10/2025



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Scale 1:3,000 @ A4 0 100 200 M

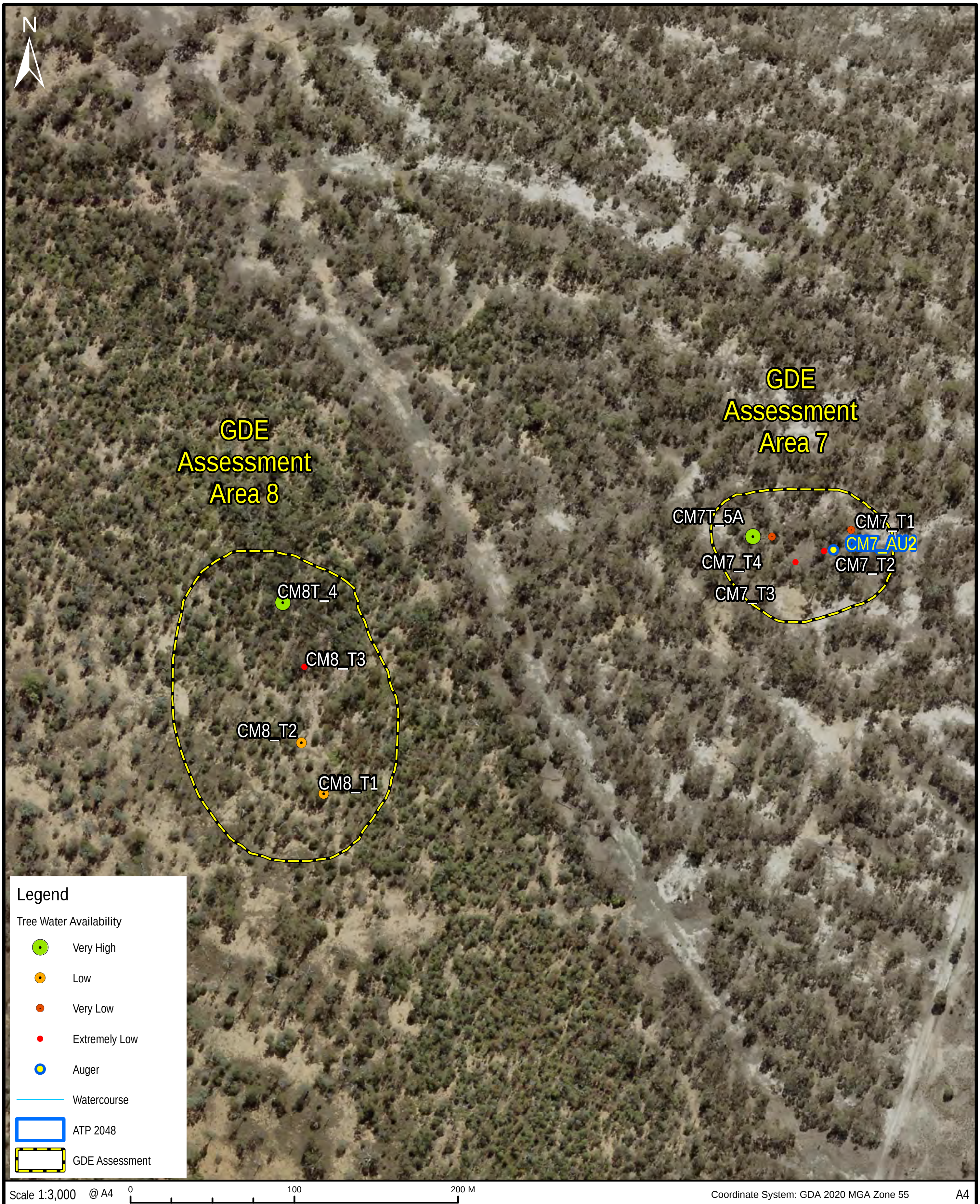
Coordinate System: GDA 2020 MGA Zone 55 A4

Appendix A6. Sampling detail at GDE Assessment Area 6

Client: Comet Ridge Mahalo North Pty Ltd
Project. Mahalo North Pty Ltd

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Drawn By DG Checked DS Date 19/10/2025



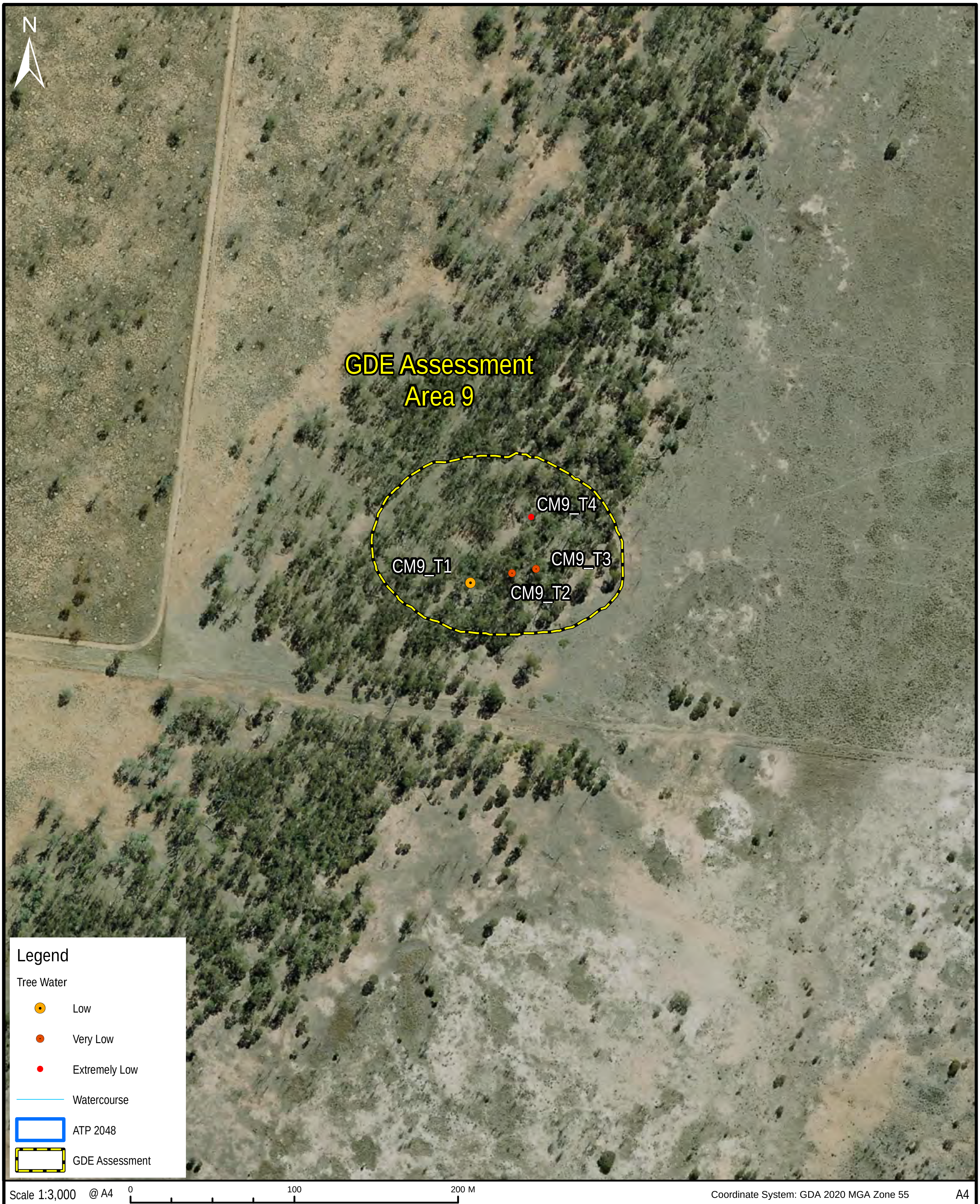
Appendix A7. Sampling detail at GDE Assessment Area 7 and GDE Assessment Area 8

WATER MARK ECO

Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Client: Comet Ridge Mahalo North Pty Ltd
Project: Mahalo North

Drawn By DG Checked DS Date 19/10/2025



Coordinate System: GDA 2020 MGA Zone 55 A4

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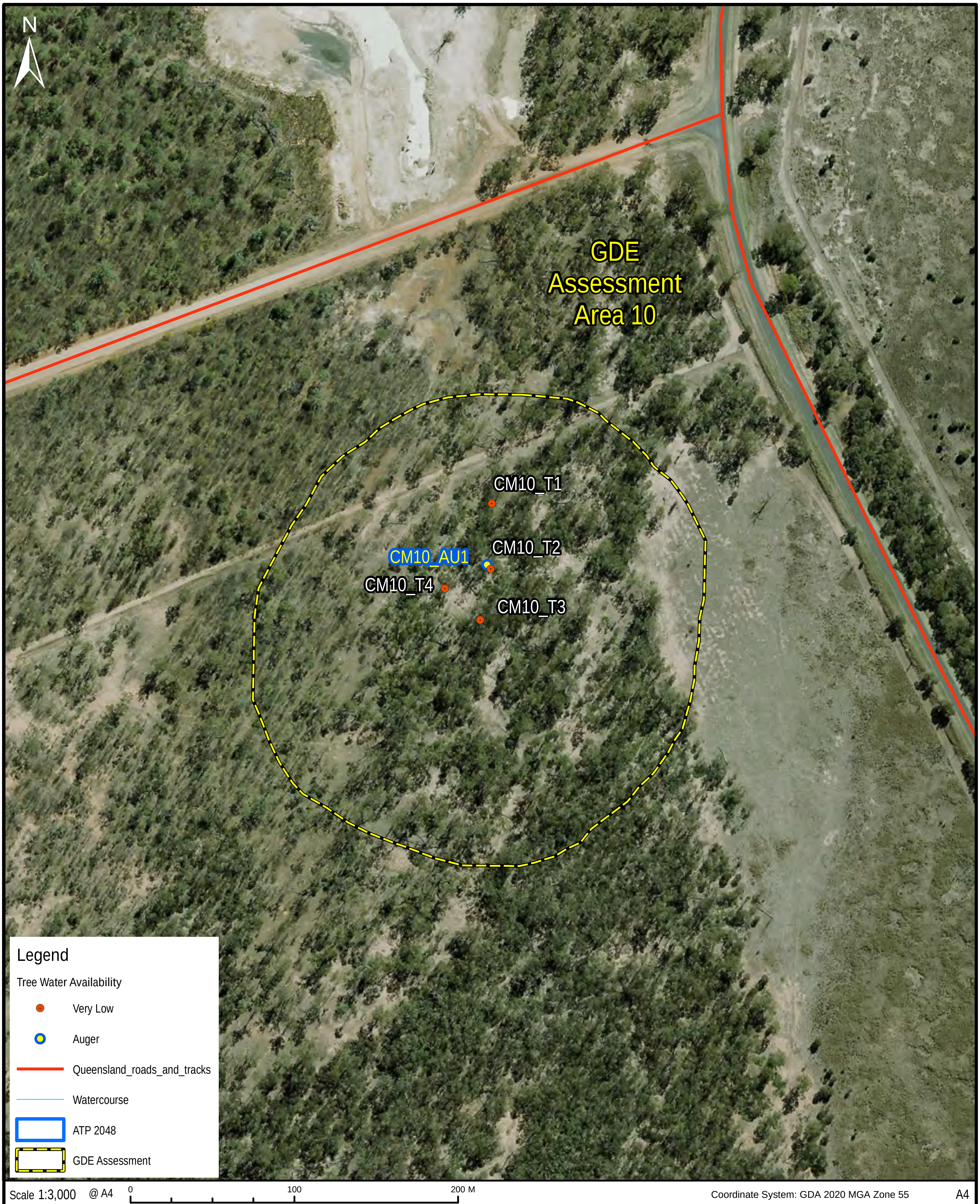
Appendix A8. Sampling detail at GDE Assessment Area 9

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Client: Comet Ridge Mahalo North Pty Ltd
Project: Mahalo North

Drawn By DG Checked DS Date 19/10/2025



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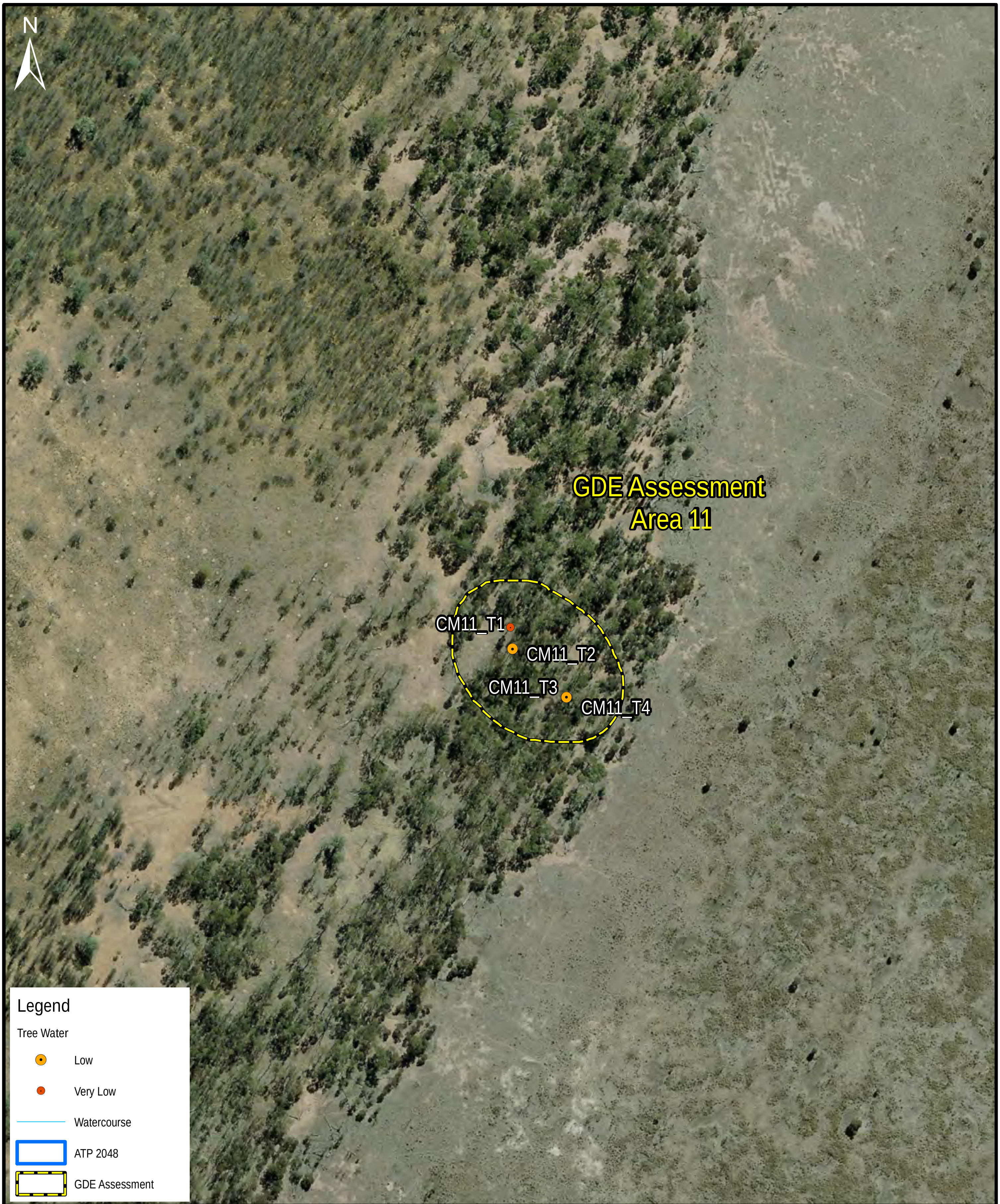
Appendix A9. Sampling detail at GDE Assessment Area 10

Client:	Comet Ridge Mahalo North Pty Ltd
Project:	Mahalo North

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Drawn By DG Checked DS Date 19/10/2025



Scale 1:3,000 @ A4 0 100 200 M

Coordinate System: GDA 2020 MGA Zone 55 A4

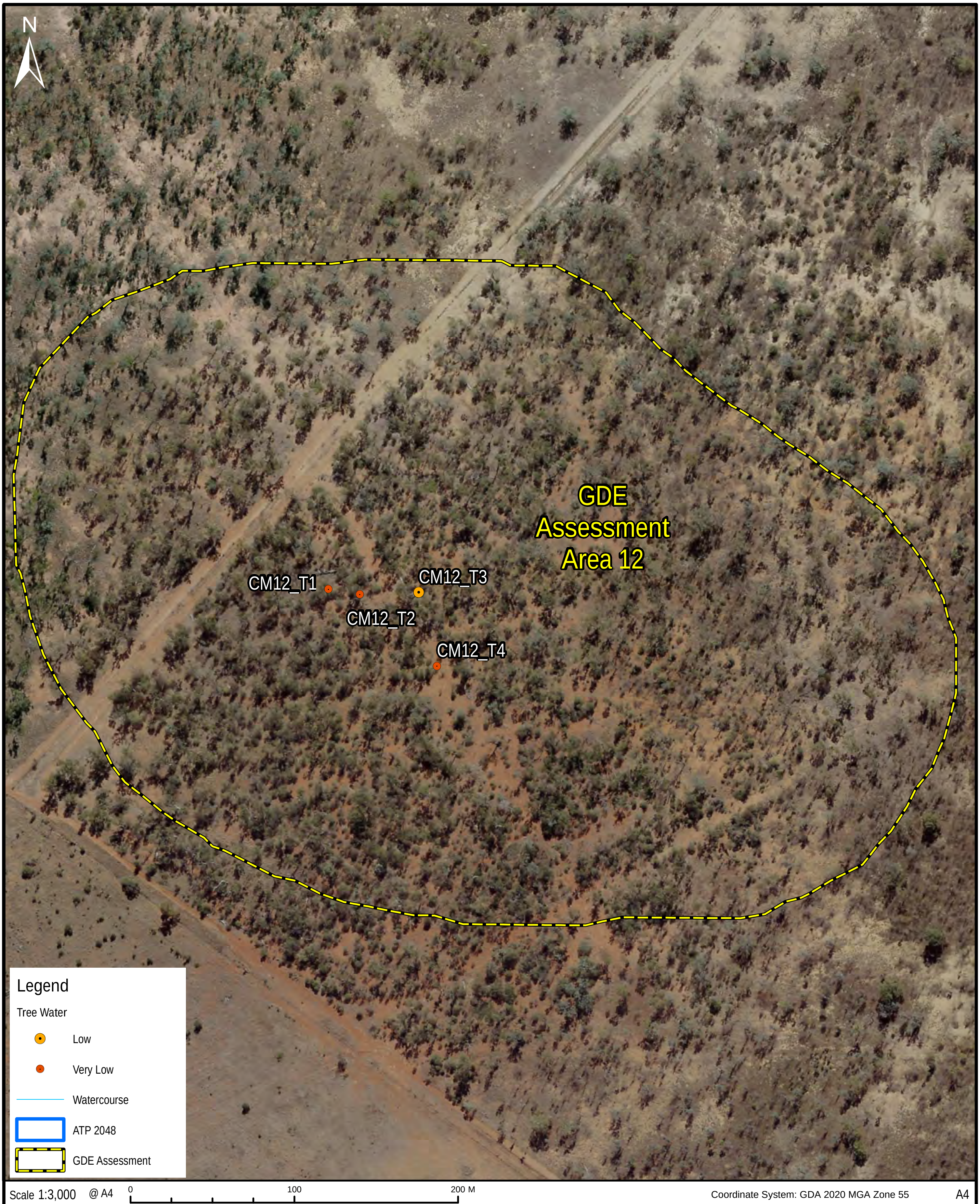
Appendix A10. Sampling detail at GDE Assessment Area 11

Client: Comet Ridge Mahalo North Pty Ltd

Project. Mahalo North

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Drawn By DG Checked DS Date 19/10/2025



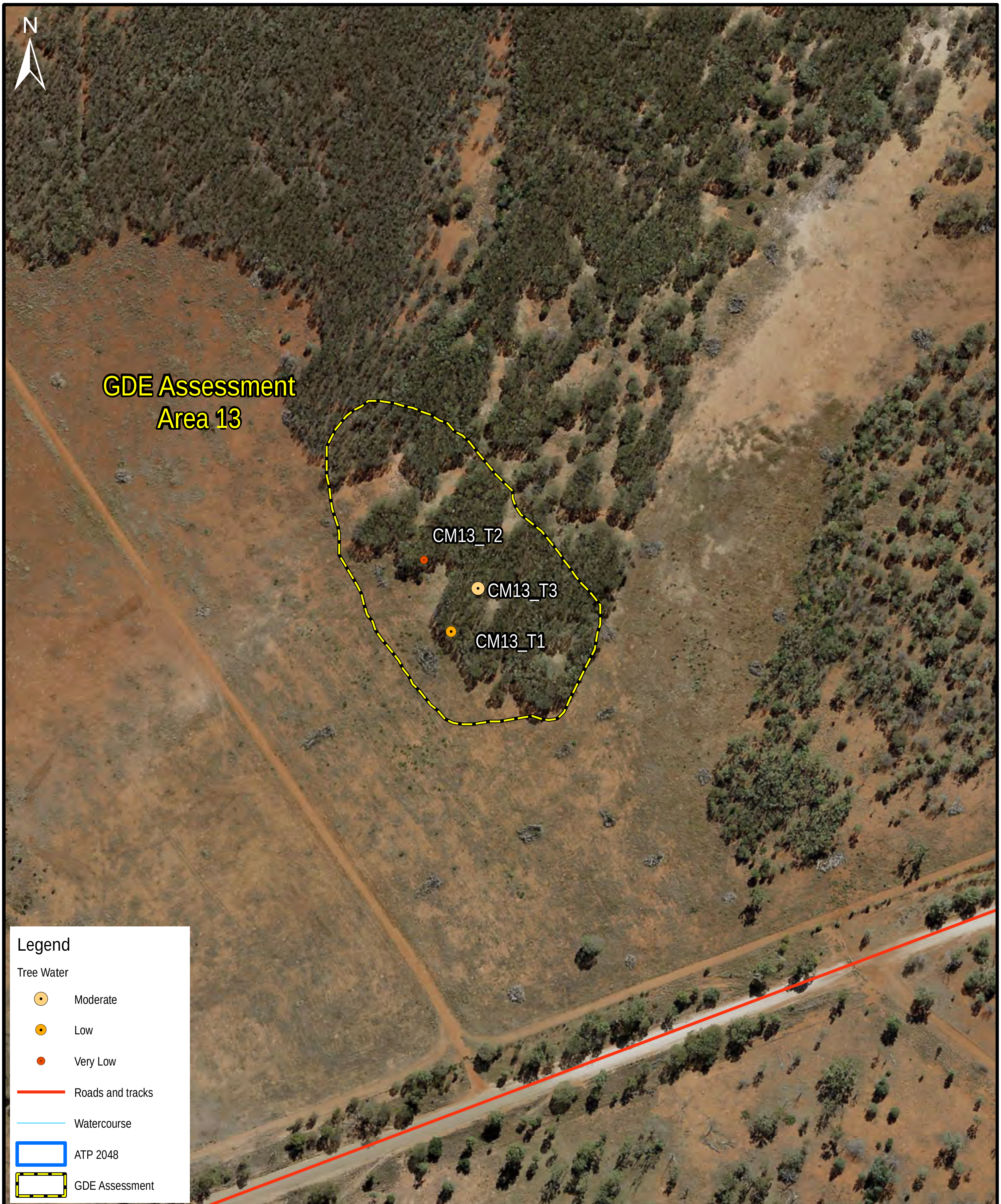
Appendix A11. Sampling detail at GDE Assessment Area 12

WATER MARK ECO

Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Client: Comet Ridge Mahalo Pty Ltd
Project: Mahalo North

Drawn By DG Checked DS Date 19/10/2025



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Scale 1:3,000 @ A4 0 100 200 M

Coordinate System: GDA 2020 MGA Zone 55 A4

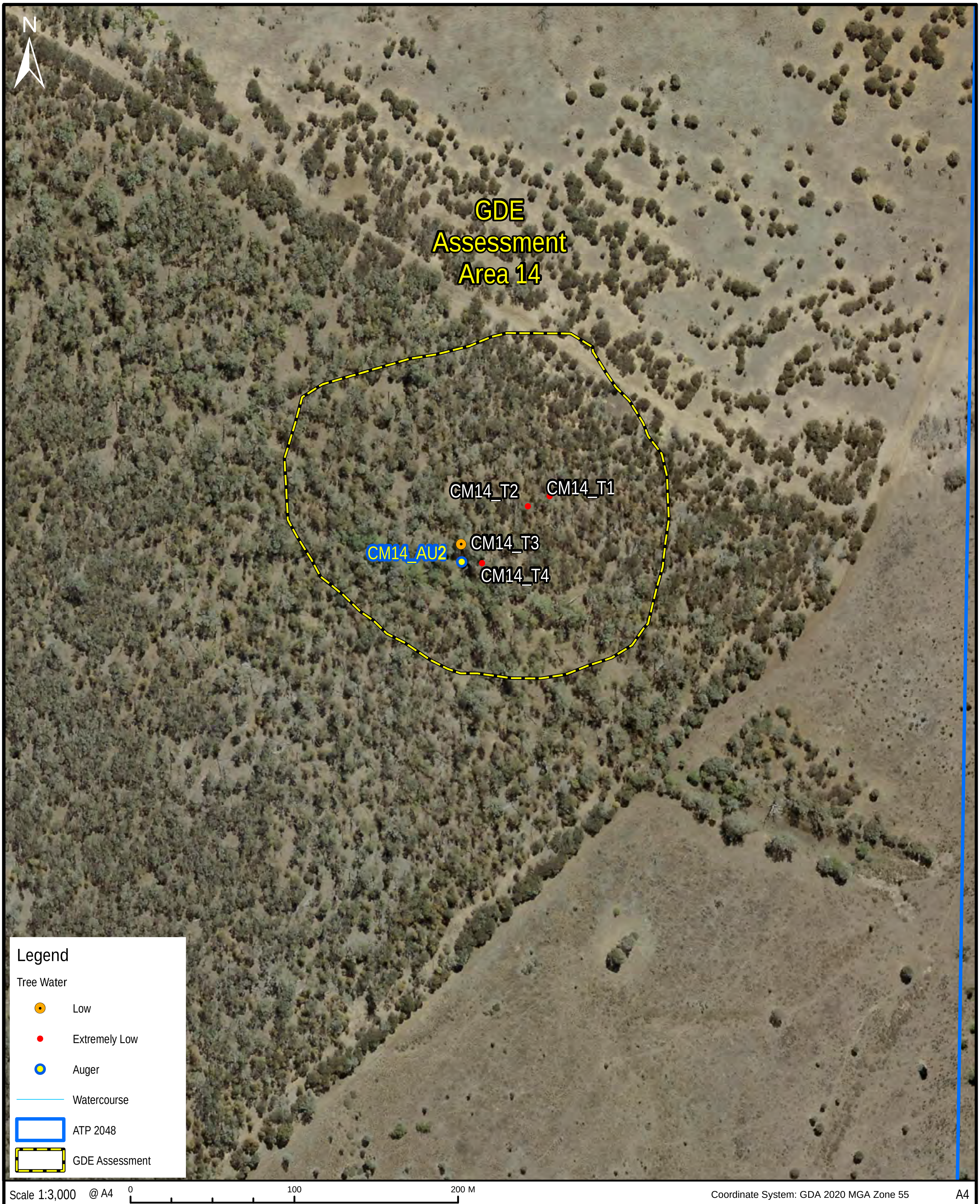
Appendix A12. Sampling detail at GDE Assessment Area 13

WATER MARK ECO

Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Client: Comet Ridge Mahalo North Pty Ltd
Project: Mahalo North

Drawn By DG Checked DS Date 19/10/2025



Appendix A13. Sampling detail at GDE Assessment Area 14

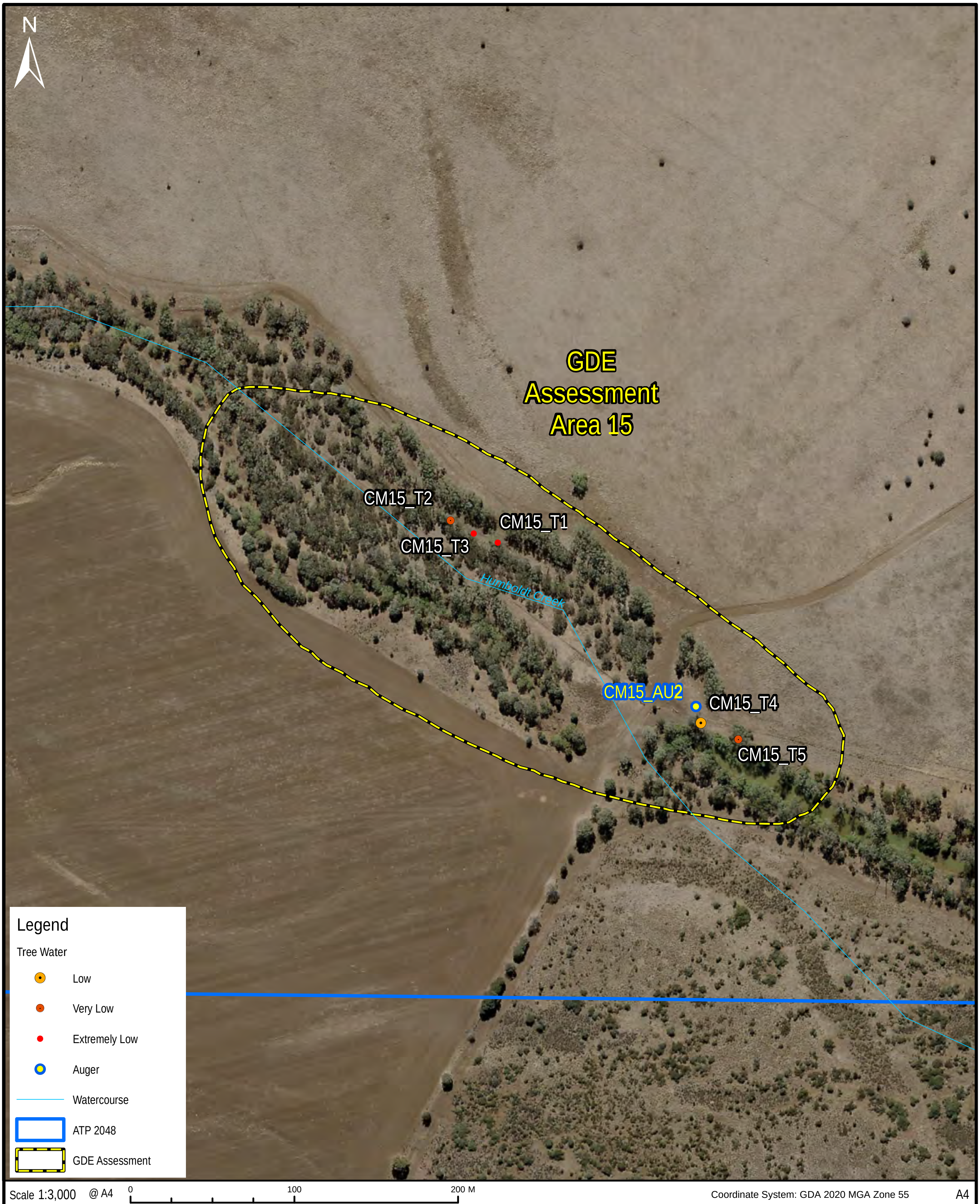
WATER MARK ECO

Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Client: Comet Ridge Mahalo North Pty Ltd

Project. Mahalo North

Drawn By DG Checked DS Date 19/10/2025



Appendix A14. Sampling detail at GDE Assessment Area 15

WATER MARK ECO
Kenmore, Qld 4069
Mobile: 0447 822 119
www.3denvironmental.com.au

Client: Comet Ridge Mahalo North Pty Ltd
Project Mahalo North

Drawn By DG Checked DS Date 19/10/2025

Appendix C. Soil Moisture Potentials-Raw Data_EV2

Sample	Type	Project	Date Sampled		SMP Measurements
CM14_AU1_0.1	Soil	Comet Mahalo	8/08/2025	Dark grey silty clay.	-2.26
CM14_AU1_0.3	Soil	Comet Mahalo	8/08/2025	Dark grey silty clay.	-2.97
CM14_AU1_0.5	Soil	Comet Mahalo	8/08/2025	Dark grey silty clay. Slightly moist.	-2.72
CM14_AU1_0.75	Soil	Comet Mahalo	8/08/2025	Dark grey silty clay. Slightly moist.	-3.41
CM14_AU1_1.00	Soil	Comet Mahalo	8/08/2025	Dark grey silty clay. Slightly moist.	-3.2
CM14_AU1_1.25	Soil	Comet Mahalo	8/08/2025	Dark grey silty clay with calcrete nodules.	-3.37
CM14_AU1_1.55	Soil	Comet Mahalo	8/08/2025	Dark grey silty clay with calcrete nodules.	-3.14
CM15_AU2_0.1	Soil	Comet Mahalo	7/08/2024	Dark brown silty clay. Moist.	-1.77
CM15_AU2_0.30	Soil	Comet Mahalo	7/08/2024	Dark brown silty clay. Moist.	-3.47
CM15_AU2_0.50	Soil	Comet Mahalo	7/08/2024	Dark brown hardened clay loam.	-3.49
CM15_AU2_0.75	Soil	Comet Mahalo	7/08/2024	Dark brown hardened clay loam.	-4.02
CM15_AU2_1.00	Soil	Comet Mahalo	7/08/2024	Dark brown hardened clay loam.	-2.9
CM15_AU2_1.50	Soil	Comet Mahalo	7/08/2024	Dark brown hardened clay loam.	-2.53
CM15_AU2_2.0	Soil	Comet Mahalo	7/08/2024	Dark brown hardened clay loam.	-3.56
CM15_AU2_2.30	Soil	Comet Mahalo	7/08/2024	Dark brown hardened clay loam.	-3.86
CM15_AU2_2.50	Soil	Comet Mahalo	7/08/2024	Dark brown hardened clay loam.	-4.06
CM15_AU2_2.80	Soil	Comet Mahalo	7/08/2024	Dark brown hardened clay loam.	-3.84
CM3_AU2_0.1	Soil	Comet Mahalo	6/08/2024	Grey fine silty sand.	-2.37
CM3_AU2_0.3	Soil	Comet Mahalo	6/08/2024	Grey-orange fine silty sand.	-2.26
CM3_AU2_0.5	Soil	Comet Mahalo	6/08/2024	Orange fine silty sand.	-3.3
CM3_AU2_0.75	Soil	Comet Mahalo	6/08/2024	Orange fine clayet sand.	-4.14
CM3_AU2_1.0	Soil	Comet Mahalo	6/08/2024	Orange fine clayey sand.	-4.68
CM3_AU2_1.25	Soil	Comet Mahalo	6/08/2024	Orange mottled sandy clayey with gravel	-3.32
CM3_AU2_1.5	Soil	Comet Mahalo	6/08/2024	Grey brown loamy clay.	-4.12
CM7_AU2_0.1	Soil	Comet Mahalo	5/08/2025	Grey fine sandy clay. Coarse tree roots observed.	-0.27
CM7_AU2_0.3	Soil	Comet Mahalo	5/08/2025	Grey clayey sand to sandy clay with some gravel.	-4.5
CM7_AU2_0.5	Soil	Comet Mahalo	5/08/2025	Grey fine sandy clay to clayey sand.	-3.47
CM7_AU2_0.75	Soil	Comet Mahalo	5/08/2025	Grey fine sandy clay with minor gravel.	-3.79
CM7_AU2_1.0	Soil	Comet Mahalo	5/08/2025	Grey clayey sand to sandy clay.	-5.47
CM7_AU2_1.5	Soil	Comet Mahalo	5/08/2025	Grey brown sandy clay.	-4.87
CM7_AU2_2.0	Soil	Comet Mahalo	5/08/2025	Grey clayey sand to sandy clay.	-4.73

Sample	Type	Project	Date Sampled		SMP Measurements
CM7_AU2_2.25	Soil	Comet Mahalo	5/08/2025	Grey brown clayey sand with strong mottling.	-5.68
CM7_AU2_2.5	Soil	Comet Mahalo	5/08/2025	Grey brown sandy clay to clayey sand. Mottled.	-4.63
CM7_AU2_2.75	Soil	Comet Mahalo	5/08/2025	Grey brown sandy clay to clayey sand. Mottled.	-4.61

Appendix D. Stable Isotope Results

Sample	Type	Event	δ 18O VSMOW	δ 2H VSMOW	d-excess	lc-excess
Clermont Mar-Apr-08	Rainfall	EV1	-1.77	-2.1	12.06	0.06
Clermont Mar-Apr-08	Rainfall	EV1	-3.49	-13.9	14.02	0.00
RAIN MOR 19-11	Rainfall	EV1	-0.21	7.39	9.07	-0.94
RAIN MOR_171121_1806	Rainfall	EV1	0.78	15.2	8.96	-0.01
RAIN MOR_181121_0806	Rainfall	EV1	2.72	28.79	7.03	0.30
Rainfall_SWC_13.05	Rainfall	EV1	-2.79	-8.29	14.03	0.73
Rainfall_SWC_19.30_270624	Rainfall	EV1	-4.43	-22.01	13.43	-1.48
Rainfall_SWC_21.00_270624	Rainfall	EV1	-4.7	-20.91	16.69	1.08
RAINFALLDYS_23112025	Rainfall	EV1	-1.24	1.74	11.66	0.26
CM14_AU1_0.1	Soil	EV1	-0.2	1.9	3.50	-5.77
CM14_AU1_0.3	Soil	EV1	-1.4	-12.21	-1.01	-10.92
CM14_AU1_0.5	Soil	EV1	-3.9	-19.89	11.31	-2.78
CM14_AU1_0.75	Soil	EV1	-4.62	-19.46	17.50	1.87
CM14_AU1_1.00	Soil	EV1	-3.99	-18.29	13.63	-0.85
CM14_AU1_1.25	Soil	EV1	-2.13	-8.8	8.24	-3.63
CM14_AU1_1.5	Soil	EV1	-5.07	-20.28	20.28	3.82
CM14_AU1_1.6	Soil	EV1	-4.65	-16.95	20.25	4.23
CM15_0.1	Soil	EV1	0.59	0.24	-4.48	-11.90
CM15_0.15	Soil	EV1	-1.25	-8.89	1.11	-8.93
CM15_0.25	Soil	EV1	-2.95	-14.99	8.61	-4.15
CM15_0.5	Soil	EV1	-3.5	-16.33	11.67	-2.05
CM15_1.0	Soil	EV1	-3.64	-14.57	14.55	0.31
CM15_1.25	Soil	EV1	-3.77	-10.21	19.95	4.87
CM15_1.5	Soil	EV1	-3.35	-19.15	7.65	-5.40
CM15_1.75	Soil	EV1	-4.32	-24.36	10.20	-4.17
CM15_2.0	Soil	EV1	-2.12	-6.23	10.73	-1.45
CM15_2.25	Soil	EV1	-4.36	-22.47	12.41	-2.29
CM15_2.5	Soil	EV1	-4.77	-24.86	13.30	-1.94
CM15_2.75	Soil	EV1	-4.54	-24.19	12.13	-2.72
CM3_AU1_0.1	Soil	EV1	-0.32	-6.89	-4.33	-12.70
CM3_AU1_0.2	Soil	EV1	-0.81	-12.83	-6.35	-14.96
CM3_AU1_0.5	Soil	EV1	-3.09	-17.19	7.53	-5.23
CM3_AU1_0.75	Soil	EV1	-4.16	-19.73	13.55	-1.10
CM3_AU1_1.0	Soil	EV1	-4.71	-22.64	15.04	-0.37
CM3_AU1_1.25	Soil	EV1	-4.04	-18.09	14.23	-0.38
CM7_AU1_0.2	Soil	EV1	1.68	-3.19	-16.63	-21.34
CM7_AU1_0.3	Soil	EV1	-1.99	-12.38	3.54	-7.57
CM7_AU1_0.5	Soil	EV1	-2.97	-19.14	4.62	-7.64
CM7_AU1_0.75	Soil	EV1	-3.44	-18.46	9.06	-4.26
CM7_AU1_1.0	Soil	EV1	-3.61	-19.41	9.47	-4.08
CM7_AU1_1.25	Soil	EV1	-3.53	-17.59	10.65	-2.97
CM7_AU1_1.5	Soil	EV1	-2.86	-13.15	9.73	-3.08

Sample	Type	Event	δ 18O VSMOW	δ 2H VSMOW	d-excess	lc-excess
CM7_AU1_1.8	Soil	EV1	-3.51	-15.89	12.19	-1.61
CM7_AU1_2.1	Soil	EV1	-3.58	-14.51	14.13	0.00
CM7_AU1_2.5	Soil	EV1	-3.82	-14.89	15.67	1.10
CM7_AU1_2.8	Soil	EV1	-3.78	-18.11	12.13	-1.94
MB-MB5-R	Water_Ground	EV1	-2.7	-20	1.60	-9.99
MN-MB1-a	Water_Ground	EV1	-4.2	-31	2.60	-10.66
MN-MB6-b	Water_Ground	EV1	-3.1	-21	3.80	-8.49
CM15_SW1	Water_Surface	EV1	-1.68	-15.99	-2.55	-12.55
CM1_T1	Xylem	EV1	-2.08	-14.79	1.85	-9.13
CM1_T2	Xylem	EV1	-2.06	-13.42	3.06	-8.06
CM10_T2	Xylem	EV1	-1.74	-10.91	3.01	-7.78
CM11_T1	Xylem	EV1	-1.99	-16.51	-0.59	-11.16
CM11_T2	Xylem	EV1	-1.69	-13.13	0.39	-10.00
CM11_T3	Xylem	EV1	-0.57	-9.32	-4.76	-13.33
CM12_T1	Xylem	EV1	-2.86	-13.72	9.16	-3.58
CM12_T2	Xylem	EV1	-2.59	-12.98	7.74	-4.54
CM12_T4	Xylem	EV1	-2.1	-13.54	3.26	-7.93
CM14_T1	Xylem	EV1	-2.15	-11.37	5.83	-5.75
CM14_T2	Xylem	EV1	-2.71	-13.08	8.60	-3.91
CM14_T3	Xylem	EV1	-1.67	-9.91	3.45	-7.32
CM15_T1	Xylem	EV1	-2.4	-13.99	5.21	-6.54
CM15_T3	Xylem	EV1	-1.24	-10.73	-0.81	-10.58
CM15_T4	Xylem	EV1	-1.27	-6.78	3.38	-6.97
CM15_T5	Xylem	EV1	-0.16	-8.83	-7.55	-15.34
CM3_T1	Xylem	EV1	-2.19	-12.37	5.15	-6.38
CM3_T2	Xylem	EV1	-1.29	-6.18	4.14	-6.33
CM3_T3	Xylem	EV1	-1.18	-9.64	-0.20	-9.99
CM4_T1	Xylem	EV1	-1.98	-16.25	-0.41	-11.00
CM4_T3	Xylem	EV1	-2.19	-8.35	9.17	-2.88
CM5_T2	Xylem	EV1	-1.29	-5.83	4.49	-6.03
CM5_T4	Xylem	EV1	-1.68	-8.93	4.51	-6.41
CM6_T1	Xylem	EV1	-3.25	-16.49	9.51	-3.68
CM6_T2	Xylem	EV1	-0.34	-11.91	-9.19	-16.95
CM6_T3	Xylem	EV1	-1.09	-8.48	0.24	-9.52
CM7_T1	Xylem	EV1	-2.64	-13.19	7.93	-4.42
CM7_T2	Xylem	EV1	-2.86	-13.72	9.16	-3.58
CM8_T1	Xylem	EV1	-1.35	-12.38	-1.58	-11.37
CM8_T3	Xylem	EV1	-0.13	-3.91	-2.87	-11.24
CM8_T4	Xylem	EV1	-2.11	-10.23	6.65	-4.99
CM9_T3	Xylem	EV1	-2.04	-10.61	5.71	-5.74
CM12 AU1 0.2	Soil	EV2	-4.19	-26.07	7.45	-6.43
CM12 AU1 0.5	Soil	EV2	-2.5	-12.86	7.14	-4.97
CM14 AU1 0.1	Soil	EV2	-5.27	-31.06	11.10	-4.37

Sample	Type	Event	δ ^{18}O VSMOW	δ ^{2}H VSMOW	d-excess	lc-excess
CM14 AU1 0.3	Soil	EV2	-2.79	-18.81	3.51	-8.42
CM14 AU1 0.5	Soil	EV2	-3.49	-20.55	7.37	-5.78
CM14 AU1 0.75	Soil	EV2	-2.37	-14.94	4.02	-7.55
CM14 AU1 1.0	Soil	EV2	-2.64	-14.2	6.92	-5.30
CM14 AU1 1.25	Soil	EV2	-3.59	-14.87	13.85	-0.25
CM14 AU1 1.5	Soil	EV2	-3.08	-11.94	12.70	-0.73
CM14 AU1 1.6	Soil	EV2	-4.76	-14.66	23.42	6.87
CM15 0.1	Soil	EV2	-1.4	-9.24	1.96	-8.34
CM15 0.25	Soil	EV2	-2.51	-14.99	5.09	-6.76
CM15 0.5	Soil	EV2	-2.86	-16.67	6.21	-6.14
CM15 0.75	Soil	EV2	-3.1	-17.87	6.93	-5.76
CM15 1.0	Soil	EV2	-2.38	-19.36	-0.32	-11.33
CM15 1.25	Soil	EV2	-3.42	-21.28	6.08	-6.83
CM15 2.0	Soil	EV2	-2.86	-16.49	6.39	-5.99
CM15 2.25	Soil	EV2	-1.9	-10.47	4.73	-6.45
CM15 2.5	Soil	EV2	-3.19	-18.45	7.07	-5.74
CM15 2.75	Soil	EV2	-3.01	-21.29	2.79	-9.27
CM3 AU1 0.1	Soil	EV2	-4.83	-31.67	6.97	-7.51
CM3 AU1 0.2	Soil	EV2	-4.11	-24.69	8.19	-5.71
CM3 AU1 0.25	Soil	EV2	-3.65	-17	12.20	-1.75
CM3 AU1 0.5	Soil	EV2	-3.9	-22.49	8.71	-5.04
CM3 AU1 0.75	Soil	EV2	-2.97	-13.39	10.37	-2.64
CM3 AU1 1.0	Soil	EV2	-3.22	-17.33	8.43	-4.58
CM3 AU1 1.5	Soil	EV2	-3.39	-20.2	6.92	-6.07
CM7 AU1 0.2	Soil	EV2	-3.49	-23.34	4.58	-8.21
CM7 AU1 0.3	Soil	EV2	-1.78	-13.2	1.04	-9.53
CM7 AU1 0.5	Soil	EV2	-2.02	-13.82	2.34	-8.65
CM7 AU1 0.75	Soil	EV2	-1.51	-9.86	2.22	-8.23
CM7 AU1 1.0	Soil	EV2	-0.45	-9.36	-5.76	-14.08
CM7 AU1 1.25	Soil	EV2	-1.65	-12.54	0.66	-9.73
CM7 AU1 1.5	Soil	EV2	-2.09	-17.86	-1.14	-11.74
CM7 AU1 1.75	Soil	EV2	-3.39	-20.54	6.58	-6.37
CM7 AU1 1.8	Soil	EV2	-1.77	-17.07	-2.91	-12.96
CM7 AU1 2.1	Soil	EV2	-1.74	-20.26	-6.34	-15.91
CM7 AU1 2.5	Soil	EV2	-2.23	-15.26	2.58	-8.65
CM7 AU1 2.8	Soil	EV2	0.12	-9.21	-10.17	-17.33
MN-MB1-a	Water_Ground	EV2	-4.45	-31.36	4.24	-9.49
MN-MB6-b	Water_Ground	EV2	-2.98	-21.21	2.63	-9.38
CM15-SW2	Water_Surface	EV2	-2.75	-13.64	8.36	-4.16
CM1 T1	Xylem	EV2	-3.02	-12.33	11.83	-1.42
CM1 T2	Xylem	EV2	-1.43	-8.58	2.86	-7.59
CM10 T2	Xylem	EV2	-2.38	-24.42	-5.38	-15.73
CM11 T1	Xylem	EV2	-2.22	-21.01	-3.25	-13.71

Sample	Type	Event	δ 18O VSMOW	δ 2H VSMOW	d-excess	lc-excess
CM11 T2	Xylem	EV2	-0.71	-17.92	-12.24	-19.98
CM11 T3	Xylem	EV2	-2.13	-12.11	4.93	-6.51
CM12 T1	Xylem	EV2	-1.53	-19.64	-7.40	-16.61
CM12 T2	Xylem	EV2	-1.89	-14.07	1.05	-9.63
CM12 T4	Xylem	EV2	-1.14	-8.26	0.86	-9.03
CM14 T1	Xylem	EV2	-0.91	-8.86	-1.58	-10.92
CM14 T2	Xylem	EV2	-1.77	-17.58	-3.42	-13.40
CM14 T3	Xylem	EV2	-1.82	-12.79	1.77	-8.94
CM15 T1	Xylem	EV2	-0.77	-12.69	-6.53	-15.08
CM15 T3	Xylem	EV2	-0.28	-6.22	-3.98	-12.36
CM15 T4	Xylem	EV2	-0.26	-10.81	-8.73	-16.47
CM15 T5	Xylem	EV2	-1.33	-12.2	-1.56	-11.33
CM3 T1	Xylem	EV2	-2.32	-17.13	1.43	-9.75
CM3 T2	Xylem	EV2	-3.87	-13.43	17.53	2.66
CM3 T3	Xylem	EV2	-4	-17.56	14.44	-0.16
CM4_T1	Xylem	EV2	-1.05	-10.21	-1.81	-11.26
CM4_T3	Xylem	EV2	-1.99	-11.42	4.50	-6.74
CM5_T2	Xylem	EV2	-1.62	-10.29	2.67	-7.95
CM5_T3	Xylem	EV2	-1.19	-8.68	0.84	-9.10
CM6 T1	Xylem	EV2	-1.11	-14.63	-5.75	-14.75
CM6 T2	Xylem	EV2	-1.53	-11.68	0.56	-9.69
CM7 T1	Xylem	EV2	-1.08	-15.83	-7.19	-15.97
CM7 T2	Xylem	EV2	-1.8	-9.91	4.49	-6.55
CM8 T1	Xylem	EV2	-2.12	-20.47	-3.51	-13.84
CM8 T3	Xylem	EV2	-2.06	-18.63	-2.15	-12.59
CM8 T4	Xylem	EV2	-2.15	-22.82	-5.62	-15.70
CM9 T3	Xylem	EV2	-2.09	-22.18	-5.46	-15.50