FINAL REPORT

Threat Mitigation and Soil Hydrology for the Giant Gippsland Earthworm Habitat

Prepared by Beverley Van Praagh- Invert-Eco For Bass Coast Landcare Network

In Collaboration with Gippsland Threatened Species Action Group
Bass Coast Landcare Network
South Gippsland Landcare Network
Oates Environmental Consulting
Water Technology

Report for	Bass Coast Landcare on Behalf of the Australian Government provided as part of the Saving Native Species (Priority Species) grant
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ACKNOWLEDGMENTS

This project, *Threat Mitigation and Soil Hydrology for the Giant Gippsland Earthworm*, received funding by the Australian Government under the Saving Native Species Program and undertaken by the Gippsland Threatened Species Action Group, Bass Coast, South Gippsland Landcare Networks, Oates Environmental Consulting, Water Technology and Invert-Eco Terrestrial Invertebrate Consulting.

Invert-Eco acknowledges the strong collaboration between project partners. The combined efforts of these organisations have been critical to the successful delivery of this project.

We sincerely thank the participating landholders for providing access to their properties and for their support for monitoring, habitat protection and management activities. In particular, Paul Hardy-Smith for allowing us to install soil monitoring probes and for on-going access to his property. Burke Brandon for supporting the regenerative agriculture case study and sharing his knowledge and experience in protecting GGE whilst undertaking farming activities. Dave Sutton from the Gippsland Threatened Species Action Group did a fantastic job of frequently checking the soil probes and associated technology and dealing with issues as they arose.

We acknowledge the contribution of Michael Aberton and the Water Technology team for hydrological monitoring design, implementation and interpretation. Their insights into soil moisture dynamics have strengthened our understanding of the relationship between hydrology and GGE habitat

We also acknowledge Mick Green (Drift Media) for the development of high-quality interactive media resources, including video and interview content, supporting communication and engagement outcomes.

Invert-Eco also acknowledges the contribution of team members Mat Killin and John Hick for their assistance with field surveys, and data collection.

EXECUTIVE SUMMARY

This report presents the outcomes of the project "Threat Mitigation and Soil Hydrology in Giant Gippsland Earthworm Habitat", undertaken as part of the *Saving Native Species (Priority Species)* program. The project aimed to advance the conservation of the Giant Gippsland Earthworm (*Megascolides australis*) (GGE) through furthering our understanding of GGE habitat hydrology, on-ground protection of habitat, targeted ecological monitoring, and landholder engagement across four priority sites in the south-western Strzelecki Ranges.

GGE colonies were confirmed at all four project properties, with a total of 132 records across the sites, including 111 records documented during this project and a further 21 records previously recorded at one site. Individual records comprised detection of gurgles, fresh burrows, and egg cocoons. Surveys highlighted the species' preference for wet, clay-rich soils on south- or southeast-facing slopes and along lower drainage lines, often in areas lacking dense overstorey vegetation.

A pilot soil hydrology study undertaken at Arawata provided new insights into soil moisture dynamics within GGE habitat areas. Monitoring using permanent probes indicated strong vertical gradients in soil moisture, with upper soil layers responding rapidly to rainfall and drying events while deeper clay horizons retained relatively stable moisture levels. Moisture at approximately 80 cm depth remained comparatively stable throughout much of the monitoring period, generally around 65–70% and declining to approximately 50–55% during the driest periods. These findings suggest that deeper clay soils may provide important moisture refugia for GGE during extended dry conditions when surface soils become unsuitable.

Key project achievements included:

- 2050m of fencing to protect four high-priority GGE colonies, covering 6.2 hectares in total
- Implementation of revegetation programs using species aligned with GGE planting guidelines.
- Targeted weed control, particularly of invasive species such as Blackberry (*Rubus anglocandicans*), Willow (*Salix* spp.), Hawthorn (*Crataegus monogyna*) and ragwort (*Senecio jacobaea*).
- Establishment of vegetation monitoring plots at each site to track ecological condition.
- Design and implementation of a pilot soil hydrology monitoring program to monitor soil moisture, temperature, and oxygen conditions across various habitat zones using in-ground probes.

The project also delivered significant community and partner engagement outcomes:

- On-ground works were delivered by South Gippsland Landcare Network and supported by participating landholders
- The Bunurong Land Council Aboriginal Corporation's Balirt Biik (Strong Country) Eastern Team was involved for the first time in GGE conservation activities, supporting revegetation efforts.
- Project results were shared via field days, a web based interactive video, and an expanded online GGE information portal at www.giantearthworm.org.au. in addition to the Bass Coast Landcare Network, South Gippsland Landcare Network and Gippsland Threatened Species Action Group websites and via social media.

GGE habitat is defined not simply by the presence of moisture, but by the stability of subsurface moisture conditions within deep clay soils. This project demonstrates that deeper soil layers provide critical refugia during dry periods, while sustained rainfall is required to recharge these systems and support surface activity. Maintaining hydrological balance—avoiding both excessive drying and prolonged saturation—is therefore fundamental to the long-term persistence of the species.

Overall, this project has made a measurable contribution to the long-term protection of GGE colonies. It has provided new insights into the species' hydrological sensitivity, improved habitat condition through on-ground interventions, and strengthened collaborative conservation networks in South and West Gippsland. The tools, datasets, and partnerships developed through this work will inform future research, habitat restoration and conservation for this nationally significant species.

This project received grant funding from the Australian Government Saving Native Species Program and was undertaken by the Gippsland Threatened Species Action Group, Bass Coast Landcare Network, South Gippsland Landcare Network, Oates Environmental Consulting and Invert-Eco Terrestrial Invertebrate Consulting.

1 INTRODUCTION

This project, delivered by the Gippsland Threatened Species Action Group under the Saving Native Species (Priority Species) program, aimed to advance the conservation of the Giant Gippsland Earthworm (*Megascolides australis*) (GGE) by addressing key threats to its survival across farmland in the south-western Strzelecki Ranges. The project focused on identifying and protecting earthworm colonies through habitat mapping, vegetation monitoring, and landholder agreements, while pioneering a pilot study on soil hydrology to better understand the species' sensitivity to moisture, temperature, and oxygen fluctuations. In collaboration with local landholders, Landcare networks, and hydrogeologists, the project integrated on-ground management, ecological research, and community education to ensure long-term resilience of this iconic invertebrate in the face of land-use pressures and climate change. Landholder engagement has played a central role, with participating properties assessed for colony presence and conservation actions tailored through site-specific planning and formal agreements.

This report focused on habitat mapping, vegetation monitoring, and Landcare-led conservation activities.

1.1 Project Aims:

- Protect GGE colonies across four priority properties through detailed mapping, landholder engagement, and targeted conservation works including fencing, weed control, and revegetation.
- Initiate a pilot soil hydrology study to monitor soil moisture, temperature, and oxygen levels over a 22-month period at one key GGE site.
- Undertake vegetation monitoring across selected GGE habitat areas to assess ecological condition and planting outcomes.
- Share project findings through field day events, web based interactive educational video, and the expansion of resources on www.giantearthworm.org.au, including use of the interactive GGE habitat tool developed in a previous project.

2 METHODS

2.1 Site Selection

2.*1.1 GGE Mapping and Landcare Site Selection*

Four priority properties were selected for GGE habitat assessments and associated Landcare activities. These sites were identified based on previous GGE records, landholder engagement, property access, and willingness to support long-term habitat protection. All selected sites were located within the core GGE range in South Gippsland and included a mix of steep, south-southeast facing slopes and lower drainage lines.

2.1.2 Habitat Assessments

Field assessments were undertaken at four properties across Kardella, Arawata, and Ranceby during June and July 2024 (Figure 1). Presence of GGEs was confirmed through detection of characteristic gurgling sounds produced by earthworm movement within burrows and by digging small quadrats to identify burrows. Most active colonies were found on steep, south-facing slopes or lower benches adjacent to drainage lines in clay-dominated pasture systems.

GGE Assessments were undertaken at:

- Site 1 Arawata (Soil moisture probes)

- Site 2 Ranceby A
- Site 3 Kardella
- Site 4 Ranceby B

2.1.3 Hydrological Monitoring

- Twelve candidate sites were initially reviewed for inclusion in a pilot soil hydrology study, with assessments based on:
- Presence of active GGE colonies;
- Site accessibility and soil characteristics;
- Landholder support and feasibility of long-term monitoring.

Monitoring sites were selected based on the spatial distribution of GGE gurgle activity recorded during a preliminary survey in May 2024. Gurgle locations were mapped across the study area, and two primary clusters were identified, representing areas of higher activity. These clusters were used to define GGE monitoring Area 1 and GGE monitoring Area 2 for subsequent monitoring. An intervening area with no detected gurgle activity was also identified and is referred to as the "no worm zone".

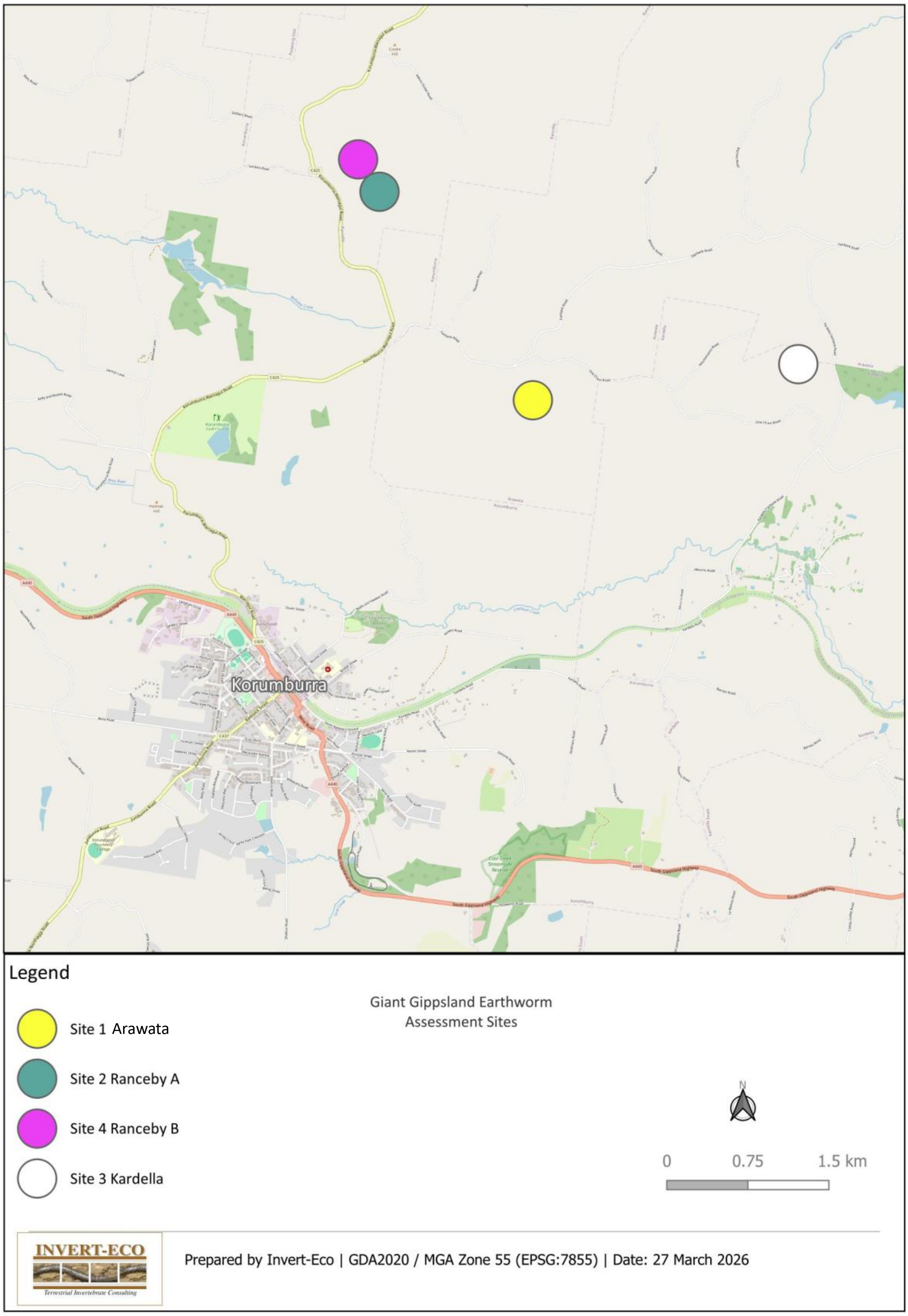
Figure 2 illustrates the distribution of gurgle activity and the basis for selection of monitoring sites.

These sites were also used for the long-term soil hydrology monitoring at Site 1, Arawata through a network of permanently installed soil probes established in May 2024 as part of the Soil Hydrology Monitoring of GGE Habitat project undertaken by Water Technology (Aberton & Phillips 2026). The probes measure soil moisture and temperature at multiple depths (10–80 cm) and soil oxygen within the upper soil profile (Figure 3). Measurements are recorded at 15-minute intervals and transmitted to the ERATOS data platform. Installation locations were selected to represent a range of site conditions including grazed pasture, revegetated areas and unoccupied comparison sites.

A summary of the monitoring program is provided in the Water Technology report (Aberton & Phillips 2026).

During the summer monitoring period (January–March 2026), portable soil moisture measurements were also undertaken using a handheld soil moisture sensor (MP406) to supplement the permanent probe dataset and provide additional information on soil moisture conditions during extended dry periods. Penetration depth of the portable probe varied depending on soil moisture conditions and soil compaction, and in very dry conditions measurements were limited to the upper soil layers.

Figure 1 GGE sites selected for field assessments



2.1.4 Giant Gippsland Earthworm Gurgle Monitoring

Transect Design for GGE Activity Monitoring

Objective:
To monitor GGE activity at Site 1-Arawata through seasonal comparison of surface gurgle counts.

Method Summary:
Monitoring was conducted during two periods (late autumn and spring) by establishing fixed transects across two active GGE colonies, coinciding with the locations of installed soil hydrology probes. Gurgles were used as an indication of GGE activity and counted systematically along transects.

GGE Monitoring Area 1 (East-West Transects):

- Transect orientation: East–west, running downslope
- Number of transects: 4
- Transect spacing: Approximately 3 m apart
- Longest transect length: ~25 m
- Survey method: Each transect was walked slowly, and all gurgles within 1 m on either side of transect line were recorded

GGE Monitoring Area 2 (North-South Transects):
- Transect orientation: North–south
- Number of transects: 4
- Transect spacing: Approximately 3 m apart
- Longest transect length: ~55 m
- Survey method: Each transect was walked slowly, and all gurgles within 1 m on either side of transect line were recorded

Monitoring Schedule:

- Monitoring 1: 15 May 2025 (Autumn)
- Monitoring 2: 16 October 2025
- An incidental assessment was undertaken by A. Oates on 19 November 2025
- Due to dense vegetation and fallen logs, the standard transect method was modified to suit local conditions, often walking in a zigzag pattern across the sites.

Monitoring continued opportunistically into the summer period (January–March 2026) using the same transect methodology, with additional portable soil moisture measurements undertaken to assess soil moisture conditions.

Rainfall data used in this report were obtained from the SILO Data Drill dataset (Queensland Government Department of Environment and Science), which provides gridded climate data derived from interpolated Bureau of Meteorology station records. SILO data were extracted for the grid cell corresponding to the Arawata monitoring site.

Figure 2 Locations selected for hydrological monitoring at Site 1 (Arawata), based on GGE colony distribution and site conditions.

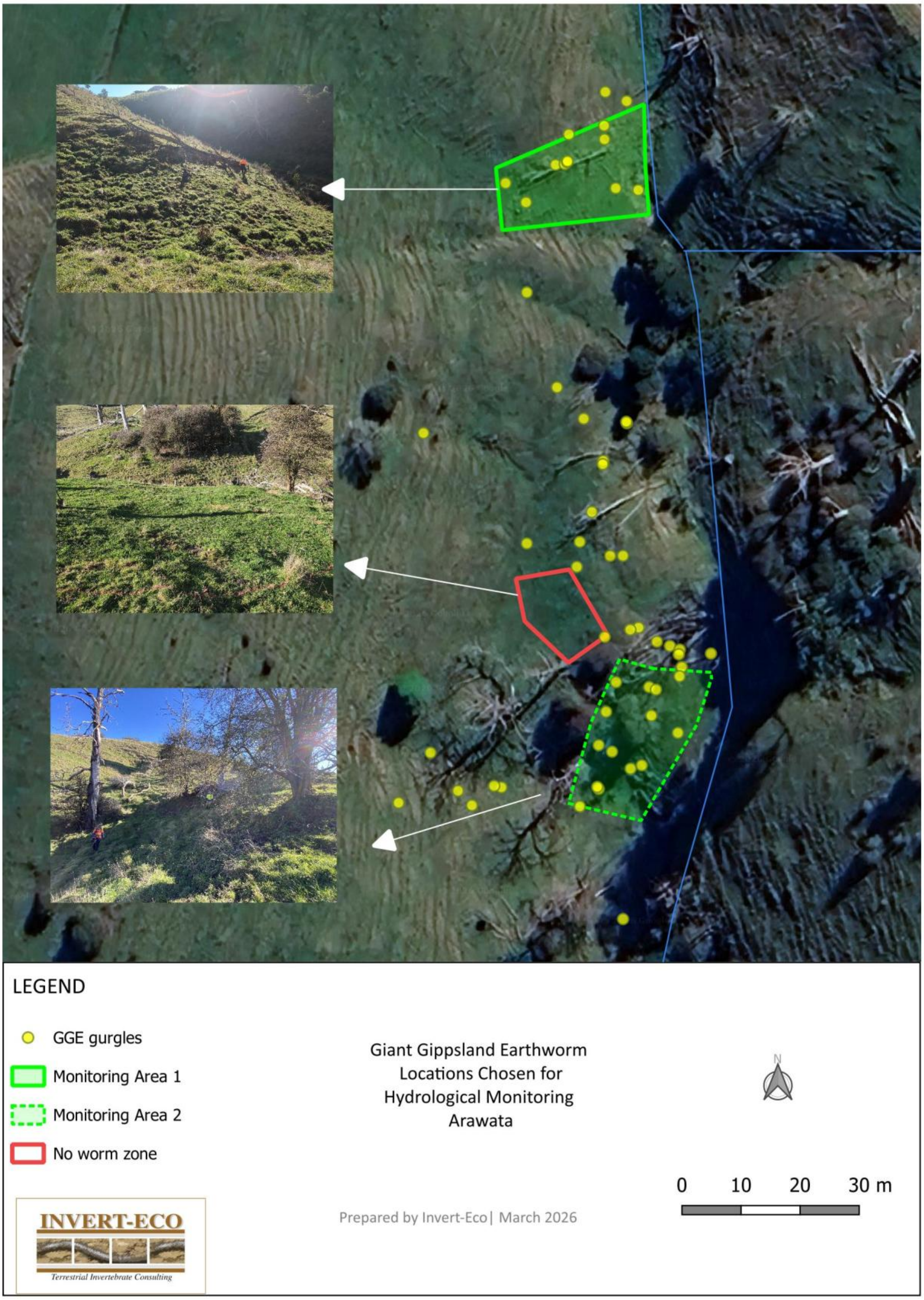
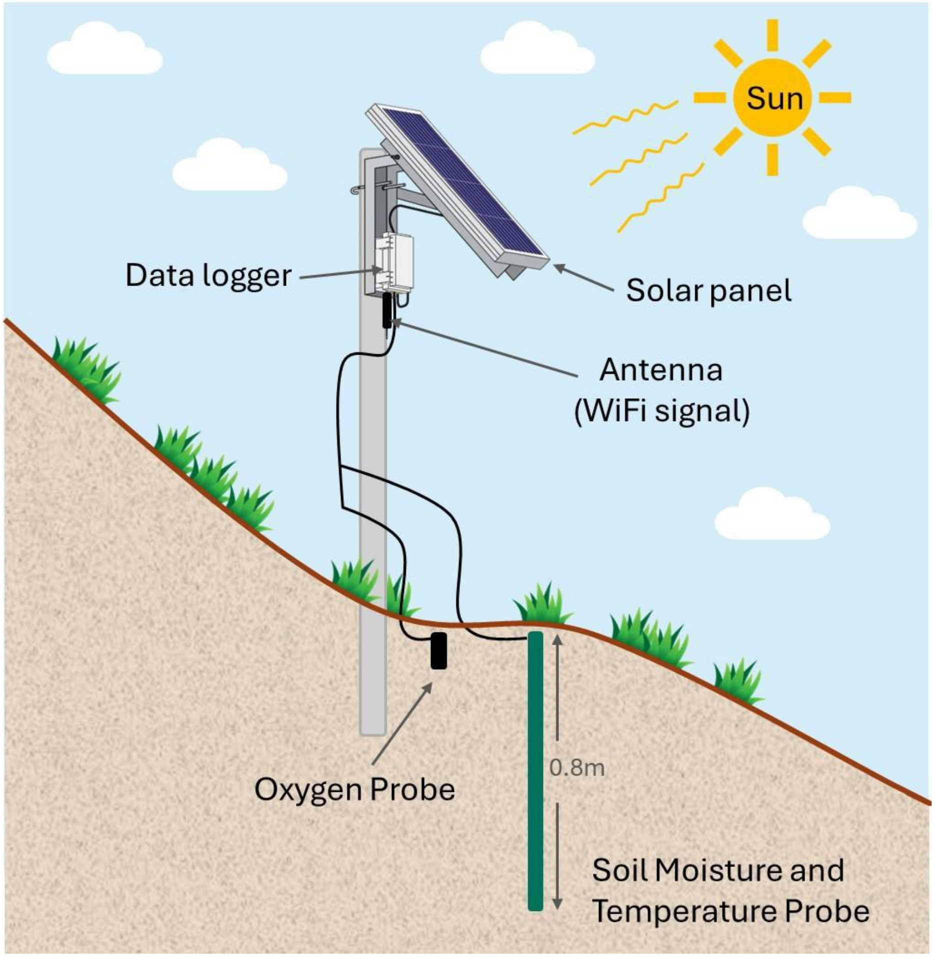


Figure 3 Diagram of soil probe set up (Source: Water Technology)



2.1.5 Vegetation Monitoring

Vegetation monitoring plots were established by Alison Oates of Oates Environmental Consulting at each study site to document vegetation composition and track changes in habitat condition over time following fencing, weed control and revegetation works. Quadrat locations were selected within areas supporting GGE colonies and in adjacent revegetation or pasture areas to allow comparison of vegetation condition.

Quadrat sizes varied depending on site conditions but generally ranged from 5 × 5 m to 10 × 10 m. Within each quadrat, all vascular plant species were recorded and classified as indigenous or non-indigenous. Observations were also made of vegetation structure, dominant ground layer species, and evidence of disturbance such as grazing, weed invasion or recent management activities. Vegetation condition is relevant to GGE habitat as groundcover composition and vegetation structure can influence soil moisture retention, shading and soil stability.

Quadrats were permanently marked where possible and photographed to enable future re-survey and comparison over time. These plots provide a baseline for assessing vegetation change and evaluating the effectiveness of habitat protection and revegetation efforts associated with the project.

2.1.6 Landcare Actions

Site-specific revegetation and fencing plans were developed by South Gippsland Landcare Network using recently updated GGE habitat planting guidelines (Fact Sheet 2 – July 2023), Appendix 1. Conservation actions were designed to:

- Exclude livestock and reduce soil compaction;
- Establish appropriate buffer zones around GGE colonies;
- Reintroduce indigenous vegetation beyond the buffer zones, while maintaining hydrological suitability around GGE colonies.

3 FINDINGS

Field assessments confirmed GGE Colonies across all four project sites in the south-western Strzelecki Ranges. Habitat was typically associated with south to south-east facing slopes and lower drainage lines with clay-dominated soils. Vegetation monitoring, hydrological monitoring and landholder-led conservation works were undertaken across these sites and are summarised below. All sites occurred within the Strzelecki Soil Association with the following soil characteristics (Agriculture Victoria VRO) (Table 1). All sites apart from Site 1 Arawata are covered by the South Gippsland Shire Council (SGSC) GGE Environmental Significance Overlay (ESO9).

3.1 GGE Site Assessments

GGE colonies were confirmed at all four project sites, with varying colony sizes, site conditions, and habitat quality. Surveys recorded a total of 111 GGE records across the sites during this project, with an additional 21 records previously documented at one site by A. Oates. In total, 132 GGE records are known across the project sites including gurgles, fresh burrows, and one egg cocoon (Table 1). Most colonies were associated with steep south- or south-east-facing slopes and lower drainage lines with moist, clay soils, characteristic of known GGE habitat preferences.

Table 1 Summarises GGE findings across the assessed sites, including the number of individual records and general habitat characteristics.

Site	No. of GGE Records	Habitat Description	Notes
Site 1- Arawata	66 (52 gurgles, 14 burrows)	Steep, south-east-facing slopes; remnant vegetation and recent revegetation	Pilot hydrology study site and vegetation monitoring, hawthorn controlled, GGE Site fenced
Site 2 -Ranceby A	GGE monitoring Area 1- 25 (21 gurgles, one hatched egg and 3 burrows) GGE monitoring Area 2- 12 (9 gurgles, one hatched egg and 3 burrows)	Linear creekline with remnant eucalypts and high weed infestation	Site fenced and revegetated; weed control undertaken, previously mapped colonies
Site 3- Kardella	12 (9 gurgles, 2 burrows)	Moist grey clays on south-east slope above tributary; mixed indigenous/exotic plantings	Burrowing Crayfish chimneys present within GGE quadrats
Site 4- Ranceby	31 (23 gurgles, 7 burrows, 1 cocoon)	Two colonies: terraced slope and linear creek bank with wet grey clays	Blackberries and hawthorn treated; indigenous riparian vegetation retained

Table 2 Strzelecki Soil Association (Victorian Resources Online Agriculture Victoria)

Strzelecki Soil Association	Details
Location	Primarily found along the Strzelecki Ranges and foothills, extending through South Gippsland, including areas like Kardella.
Parent Material	Derived from Cretaceous marine sediments (sandstones and mudstones), often deeply weathered. Some areas include basaltic influence (especially higher elevations).
Texture	Gradational profiles with loamy topsoils over clayey subsoils.
Colour	Ranges from dark brown to reddish-brown; subsoils often strongly mottled with yellow and red.
Drainage	Generally moderately well to poorly drained, especially on lower slopes.
Structure	Moderately structured clay subsoils; topsoils are friable when moist.
Soil Types	Chromosols and Kurosols dominate. Occasionally Ferrosols occur on basaltic outcrops. Sodosols may be present in wetter, lower-lying terrain.
Fertility	Moderate to low natural fertility, particularly due to acidic subsoils and aluminium toxicity. Requires lime and fertiliser inputs for productive agriculture.
Land Use	Commonly used for grazing (dairy and beef) and some forestry. Sensitive to compaction and erosion on steeper slopes.

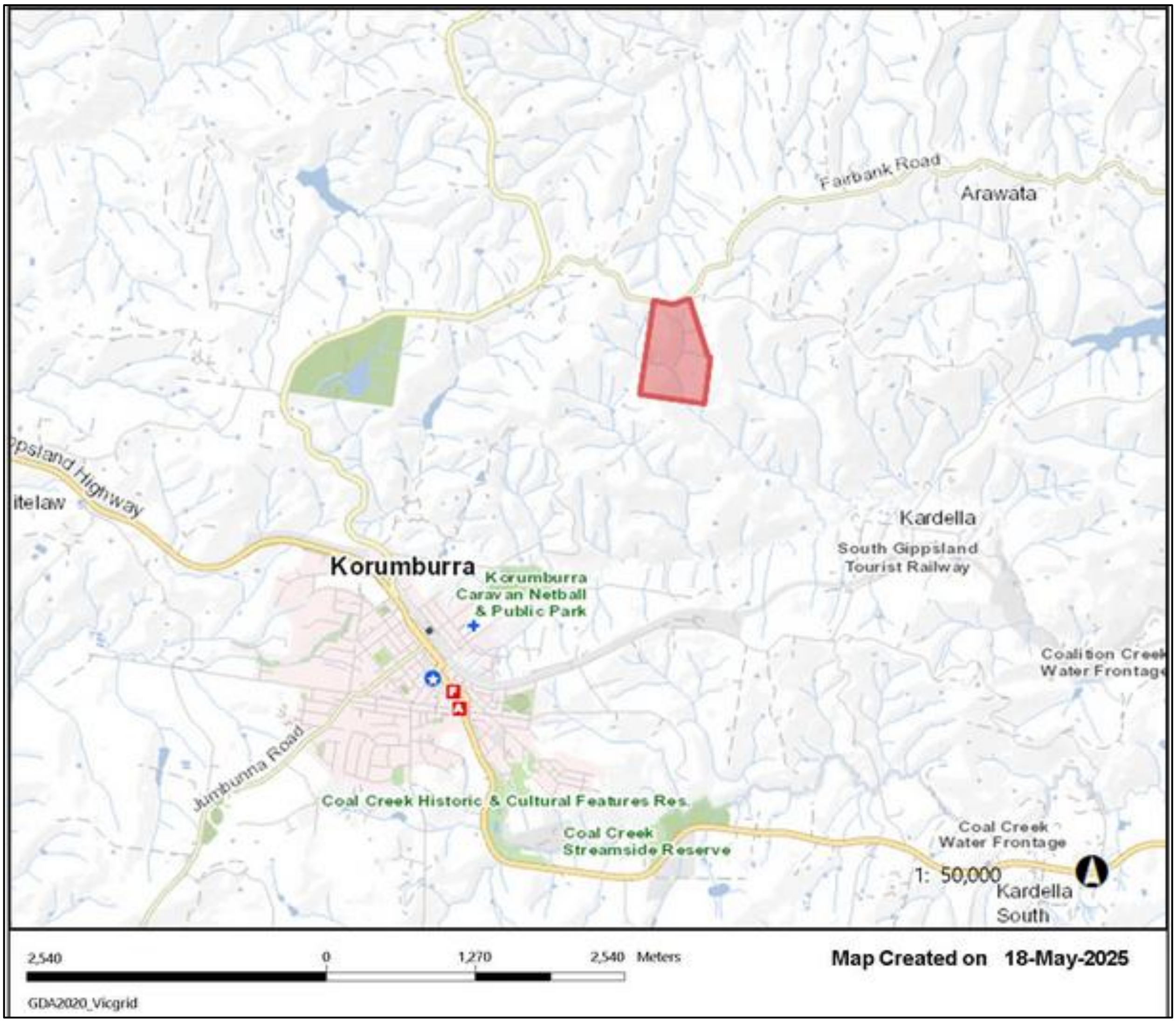
3.2 Site 1 Arawata (Figure 4)

The hydrology monitoring site at Site 1 Arawata is located within the south-western Strzelecki Ranges and forms part of a broader landscape supporting GGE habitat. The site location is shown in Figure 4. This property was selected for both habitat protection and the pilot hydrology study.

Site history and land use

The current owner has managed the property for approximately five years and runs a beef cattle operation. He has a strong interest in conservation and had already undertaken revegetation works at the northern end of the gully prior to learning about the GGE. After attending a field day on the species, he realised that GGEs were present on his property and invited Alison Oates (Oates Environmental Consulting) to visit. During this visit, the extensive nature of the GGE colonies on the property was discovered.

Figure 4 Study Site 1 - Arawata



3.2.1 GGE Assessment

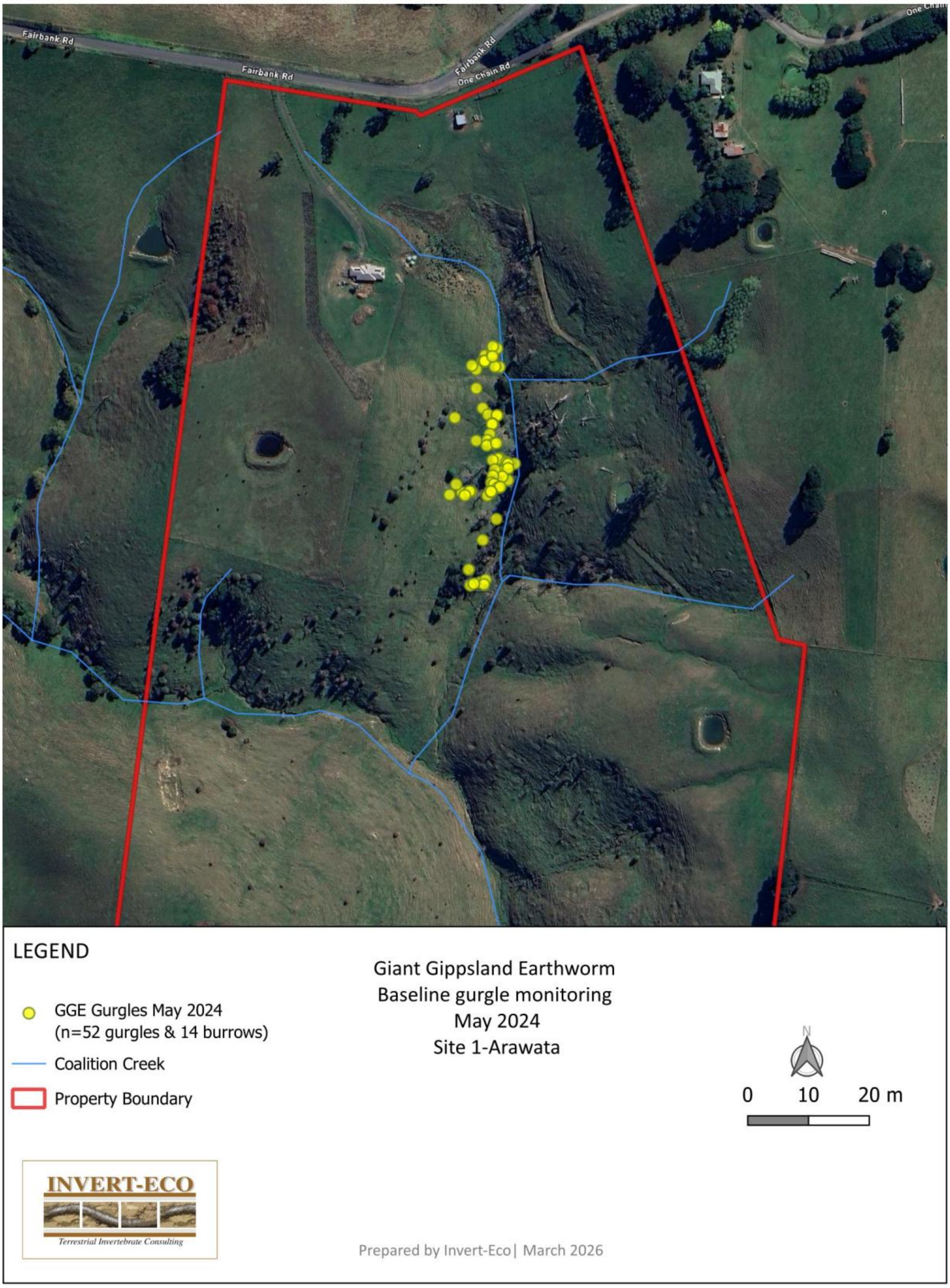
Extensive colonies of GGEs were recorded along the lower sections of steep, south-east facing slopes, confirmed by frequent gurgling sounds and the presence of burrows (Figure 5, Photo 1 and 2). A total of 66 individual records were documented, comprising 52 gurgles and 14 fresh burrows. Worms were recorded within 50 m upslope of the creek, with the majority recorded within 30 m.

Photo 1 Aerial view of steep, south-east facing slope supporting GGE habitat at GGE monitoring Area 1 Arawata (Source: Drift Media)

Photo 2 GGE habitat at Site 1 Arawata GGE monitoring Area 2

GGE burrows in clay/loam soils

Figure 5 GGE gurgles recorded in May 2024 at Site 1 Arawata over the entire south-eastern slope



3.2.2 Vegetation Monitoring

Vegetation monitoring was undertaken at each of the four study sites to document vegetation structure and composition associated with GGE habitat. Detailed results can be found in Oates (2026) and are summarised below.

Observations focused on dominant vegetation type, groundcover composition, weed presence, canopy cover and general site condition. Particular attention was given to species indicative of moist soils and areas of potential habitat degradation such as weed invasion or pasture modification. Photographic records were also taken to provide a visual baseline for future monitoring and to document any vegetation changes associated with Landcare restoration activities.

Two vegetation quadrats were set up in GGE monitoring area 1 - HAR1, HAR2 (Photo 3-5) one in monitoring area 2 (HAR3) (Photo 6) with an additional quadrat set up on the eastern side of the creek (HAR4) (Photo 7) (Figure 6).

Photo 3 View to westerly slope of the locations of quadrat sites HAR1, HAR2 on the edge of the revegetation site near the fallen log

HAR1

HAR1 is situated in GGE monitoring Area 1 in pasture adjacent to a fenced off one-year old revegetation site which will not be revegetated due to its proximity to the GGE colonies. The 10 x 10m plot is on a lower slope with a large eucalypt log in the site. The area has recently been fenced off from cattle. GGE gurgles were recorded within the quadrat. Weedy pasture grasses dominated the site with a couple of indigenous plants, Tender Brake (*Pteris tremula*) and Hairy Pennywort (*Hydrocotyle hirta*) being present. Downslope towards the gully are remnant Blackwood (*Acacia melanoxylon*) trees and a number of eucalypt stags and logs, possibly Mountain Ash (*Eucalyptus regnans*) which is growing on the eastern sides of the gully.

HAR 2

This quadrat was placed in the one-year-old revegetation site adjacent to HAR1. GGE gurgles were heard in the site. The 10 x 10m plot contained a variety of indigenous plants including Messmate (*Eucalyptus obliqua*), Blue Gum (*Eucalyptus globulus*) and Strzelecki Gum (*Eucalyptus strzeleckii*). A number of shrubs were also recorded such as Musk Daisy-bush *(Olearia argophylla*), Prickly Moses (*Acacia verticillata*), Hemp Bush (*Gynatrix pulchella*) and Common Cassinia (*Cassinia aculeata*). The ground layer was dominated by the tall pasture grass, Cocksfoot (*Dactylis glomerata*) due to the exclusion from cattle.

Photo 4 HAR1 Quadrat looking south-east to the gully

Photo 5 HAR2 Quadrat: south- east looking north-west

HAR3

One quadrat was established in GGE monitoring area 2, HAR3 (Photo 6). This quadrat was done in July 2024 and since that date the area has been fenced off from cattle. No GGE gurgles were heard in this site and the soil was a brown, sandy clay loam and drier than other sites. Plant species in the quadrat consisted of weedy pasture grasses and herbs. The site is adjacent to the gully where soil probes have been installed.

Photo 6 HAR3 Quadrat upslope from the creek

HAR4

HAR4: Quadrat on eastern side of the creek between the dead hawthorn bushes to the right and the revegetation area to the left (Photo 7).

This 10 x 10m quadrat was placed on a mid-westerly slope on the other side of the gully to the other three quadrats. GGE gurgles were heard approximately 30m downslope on a terrace adjacent to the creek. The soil is a brown loam with little clay content, and a large, old eucalypt trunk was on the eastern edge of the quadrat.

The quadrat contained weedy pasture grasses and herbs with the only indigenous plant present being the herb, Native Flax (*Linum marginale*). This area has been recently fenced and will eventually be revegetated by the landholder when funding resources become available in the future.

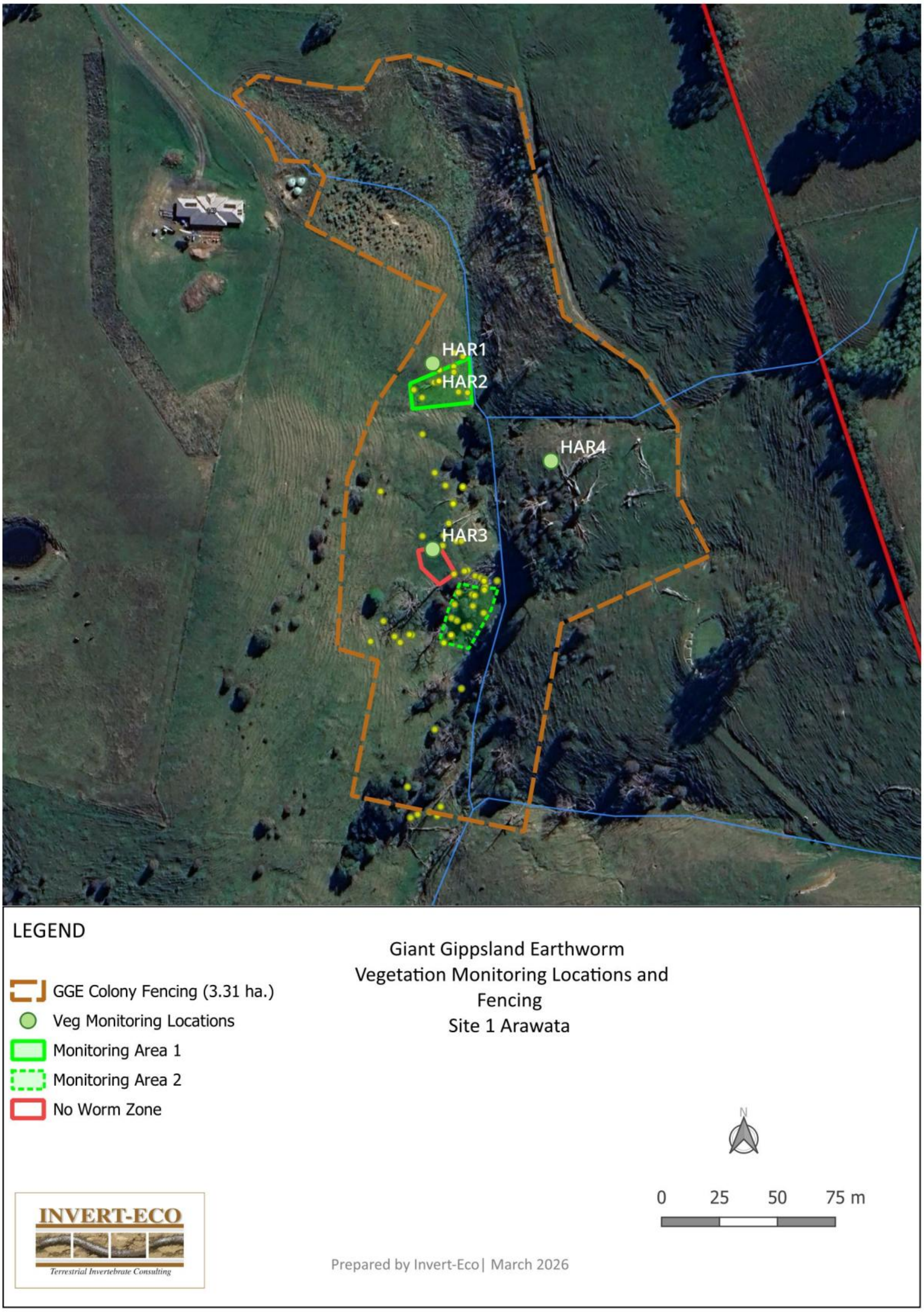
Photo 7 HAR4 Quadrat: south-east looking north-west

3.2.3 On-ground Actions

On-ground actions undertaken included (see Figure 6):

- 960m of stock-proof fencing
- 2600 seedlings planted. This included EVC-appropriate local indigenous species. A tussock/sedges/small shrub mix was used for areas above the GGE colonies on the western side of the gully, and a standard EVC mix was used on the eastern side of the gully where no GGE colonies were present.
- Weed control support – two days of weed control undertaken by a two-person professional crew, controlling hawthorn
- Weed control – landholder controlling weeds across the site including ragwort, hawthorn, thistle and blackberry
- Professional planting support provided by the Bunurong Land Council Aboriginal Corporation works crew (2 members for 1 day) and the Bass Coast Landcare Network works crew (4 members for 1 day)

Figure 6 Vegetation Monitoring Plots and Fencing at Site 1 Arawata



3.2.4 Hydrological Monitoring

Invert-Eco and Gippsland Threatened Species Action Group worked with Water Technology to implement a pilot hydrological monitoring study at Site 1- Arawata. The study aimed to establish baseline hydrological profiles associated with active GGE colonies and evaluate how soil conditions differ across revegetated, grazed, and unoccupied areas. The results will help inform future habitat management and revegetation strategies under changing climatic and land-use conditions. All probe sites were first checked for GGE to ensure that no individuals were damaged during the installation process.

A total of four monitoring sites were selected based on GGE clusters observed in the May 2024 assessment comprising (See Figure 2):

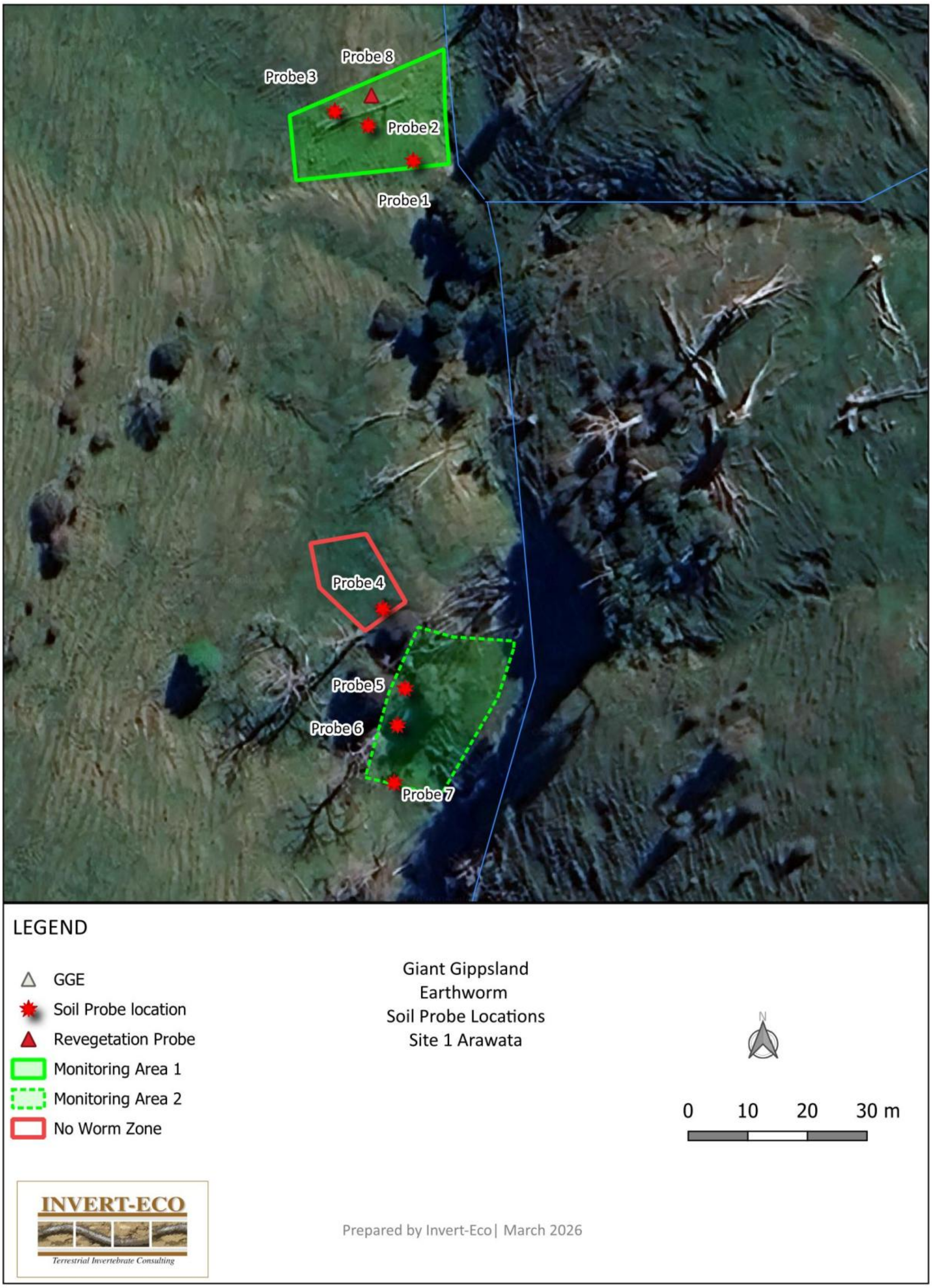
- Two active GGE colonies in grazed pasture (monitoring Area 1 and 2)
- One active colony within an early-stage revegetation area; and
- One unoccupied control site in pasture.

Seven probes were installed on May 29-30, 2024: three at active colony sites, one at an unoccupied control site, and one in an early-stage revegetation area. (Figure 7, Photo 8). Each site had soil probes measuring moisture and temperature every 10 cm from 10 to 80 cm depth, and oxygen sensors measuring soil oxygen at 20 cm below the surface.

These probes continuously monitor soil moisture, temperature, and oxygen levels, and are remotely accessed for ongoing data collection (see Aberton and Phillips 2026 for details).

Photo 8 Installing hydrological monitoring probes at Site 1 Arawata

Figure 7 Location of soil monitoring probes at Site 1 Arawata



3.2.5 Gurgle Monitoring Transects

Two counts of gurgles were undertaken within the two GGE habitat sites at Site 1 -Arawata 15 May 2025 and 16 October 2025. An earlier assessment in May 2024, which did not use transects but covered similar areas, detected 55 gurgles.

The May 2025 survey was carried out under dry conditions, more typical of late summer and early autumn, characterised by low rainfall, browning pastures, and dry soils, contrasting with the wetter conditions observed in June 2025 (Photo 9). A total of three gurgles were recorded during this survey (one in monitoring Area 1 and two in monitoring Area 2; Figure 8).

The second monitoring count in October 2025 recorded six gurgles (two in monitoring Area 1 and four in monitoring Area 2; Figure 9). Site conditions were also drier than usual (see Section 3.2.6).

On 19 November 2025, while Oates Environmental was undertaking vegetation monitoring, an incidental assessment recorded a total of six gurgles outside the transects and a further ten in the vicinity of soil probe locations. This increase is likely associated with higher rainfall during November.

Due to dense vegetation and fallen logs, the standard transect method was modified to suit local conditions, often requiring a zigzag survey pattern.

A comparison of gurgle numbers recorded in June 2024, May 2025, and October 2025 is shown in Figure 10.

Aerial view of site conditions during winter 2024

Aerial view of site conditions during Summer 2025

Photo 9 Comparison of site conditions at Arawata Site 1 during winter 2024 and summer 2025

Figure 8 Location of gurgles detected May 2025 at monitoring sites, Site 1 Arawata

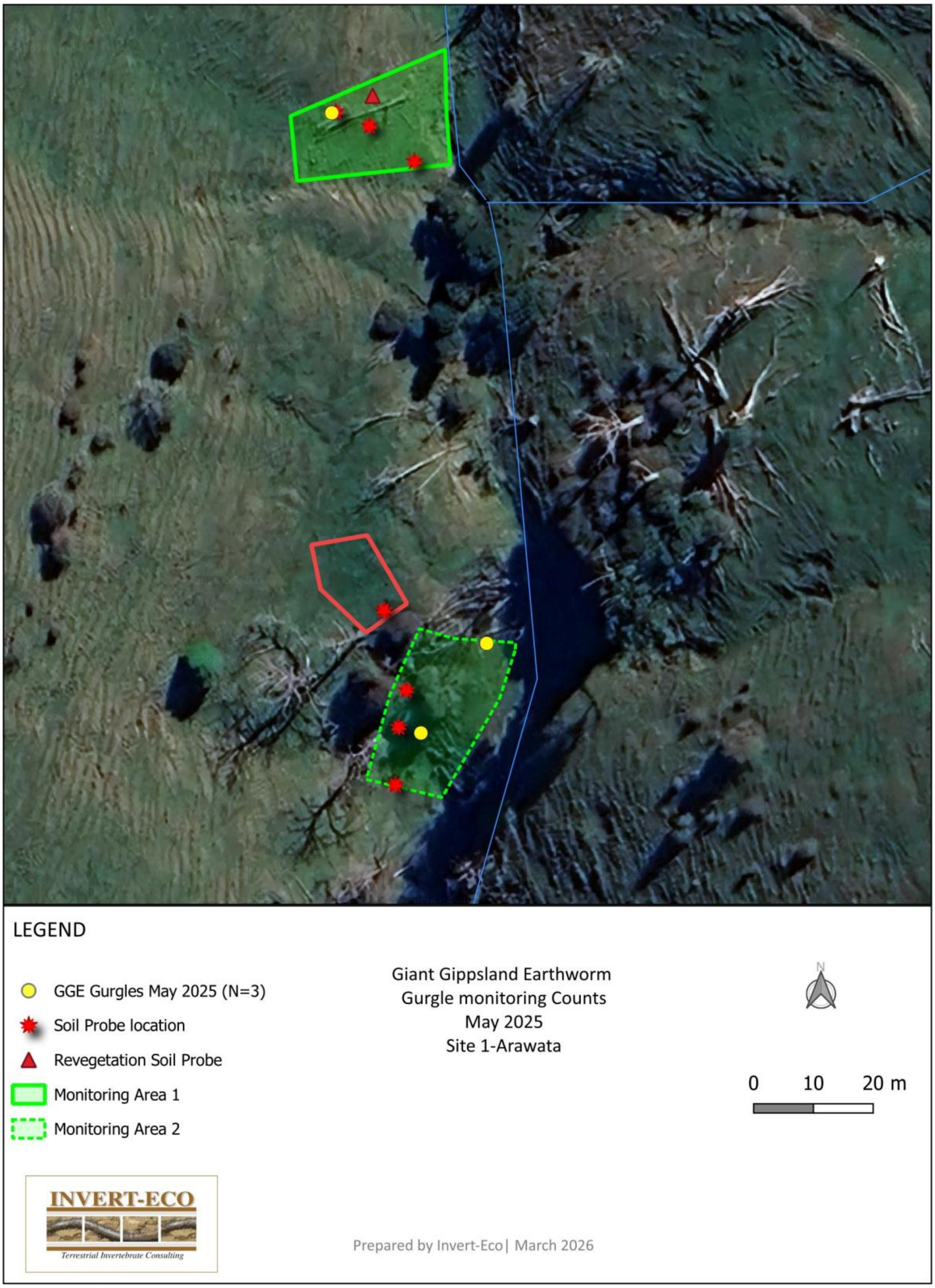


Figure 9 Location of gurgles detected October 2025 at monitoring sites, Arawata

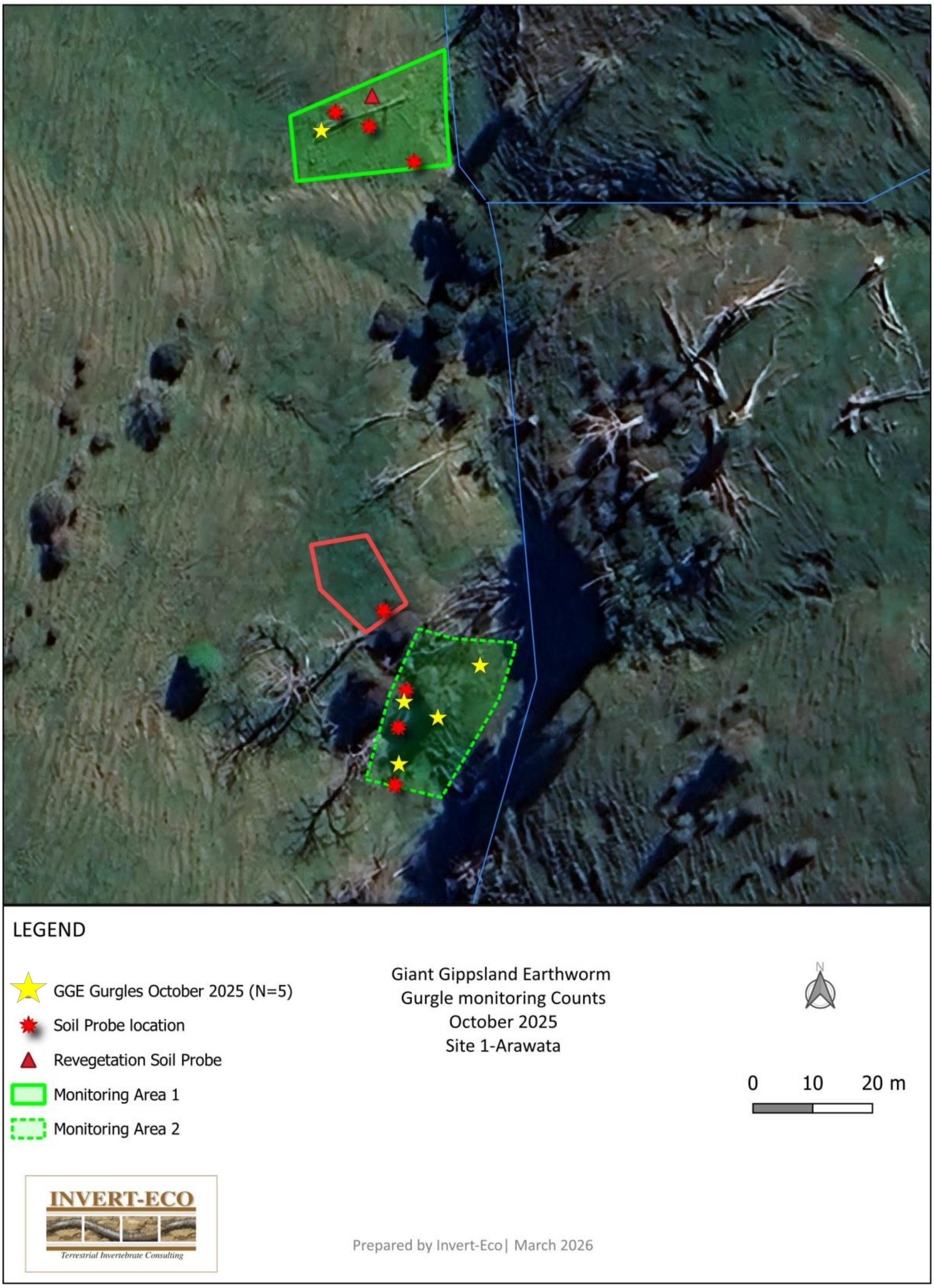


Figure 10. Spatial distribution of GGE gurgle activity across survey periods (May 2024, May 2025 and October 2025). A total of 27 gurgles were recorded within monitoring areas, with 55 additional records across the broader study site.

3.2.6 Gurgle Count and Rainfall

Rainfall data derived from the SILO Data Drill dataset indicate that 2025 was characterised by extended dry conditions during the first half of the year (Figure 11). Cumulative rainfall from January to May 2025 totalled approximately 192 mm, compared with a 10-year average of approximately 299 mm for the same period. This represents rainfall approximately 36% below average and corresponded with widespread browning of pasture and very dry surface soil conditions observed during the May monitoring survey (See Photo 9).

These dry conditions coincided with the low number of gurgles detected during the May 2025 monitoring, when only three gurgles were recorded within the established transects. Rainfall increased during winter 2025, particularly in July, which received 136.5 mm, well above the 10-year average of 82.9 mm.

Despite this winter rainfall, overall rainfall for much of 2025 remained variable and below the long-term average in several months. The October 2025 monitoring event recorded six gurgles across the transects, representing a small increase in detectable activity compared with the May survey. However, rainfall patterns and soil conditions suggest that surface moisture availability remained lower than typical seasonal conditions during parts of the monitoring period.

The high number of gurgles recorded during the May 2024 survey (55 detections; Figure 9) likely reflects the influence of substantial rainfall in the preceding month (Figure 12). SILO rainfall data indicate that July 2024 received approximately 164 mm of rainfall, nearly double the 10-year average of 83 mm for that month. This rainfall would have resulted in elevated soil moisture conditions across the site, likely promoting increased earthworm movement and the production of audible gurgles during the May survey. This pattern suggests that detectable GGE surface activity may respond to accumulated soil moisture conditions over preceding weeks rather than rainfall immediately prior to a survey.

These results highlight the strong influence of rainfall and associated soil moisture conditions on the detectability, and activity, of GGEs.

Figure 11. Monthly rainfall derived from the SILO Data Drill dataset for the grid cell corresponding to the Arawata monitoring site for 2024–2025. Rainfall totals are compared with the 10-year average monthly rainfall for the same location.

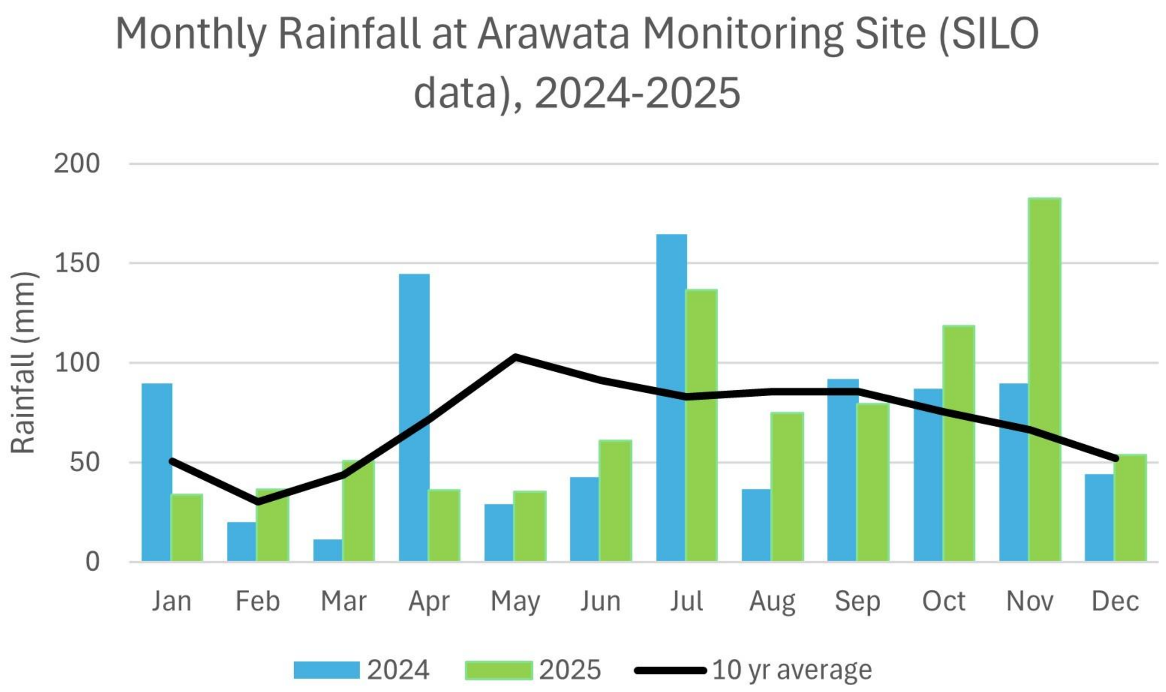
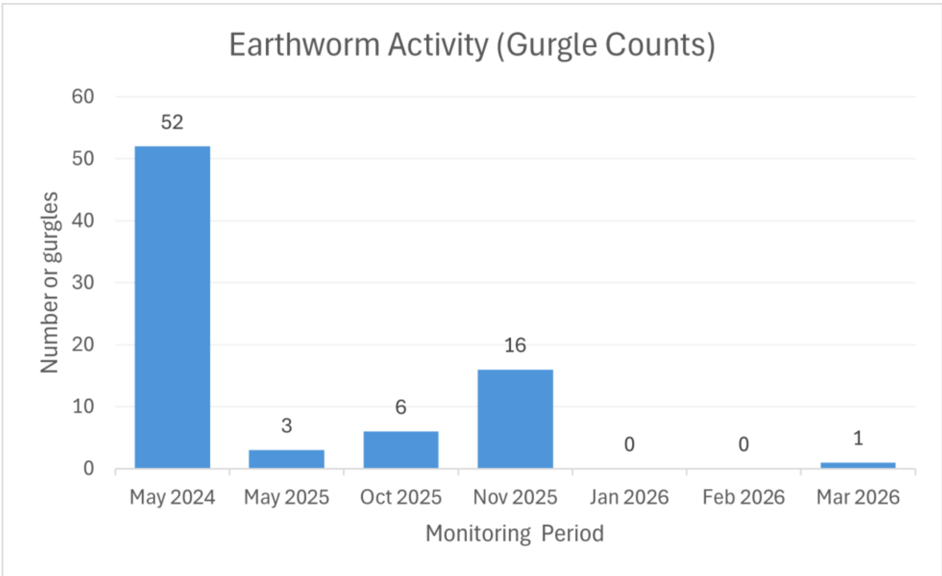


Figure 12. Earthworm activity (gurgle counts) recorded during monitoring events between 2024 and 2026. Activity was highest during the initial survey in May 2024 and lowest dry months and during summer monitoring periods. Note the November counts were opportunistic rather than quadrat based.



3.2.7 Summer 2026 Monitoring- Gurgle Activity and Soil Moisture Conditions

Contingency funding enabled continuation of GGE monitoring at the hydrology study site over the summer period (January–March 2026). This additional monitoring aims to improve understanding of GGE activity during extended dry periods which is increasingly relevant under projected climate change scenarios.

Gurgle Monitoring

Seasonal gurgle counts continued along the established transects at the hydrology monitoring site using the same methods described in Section 2.1.5. Monitoring was undertaken during January, February and early March 2026. Gurgle detections recorded during all monitoring events are summarised in Table 3.

The first summer monitoring event was conducted on 15 January 2026. No GGE gurgles were detected at either site during this survey. Site conditions were extremely dry, with hardened surface soils and no visible surface moisture. These conditions contrasted strongly with those recorded during wetter monitoring periods in 2024 and 2025, when gurgles were readily detected. The absence of gurgles during this survey is therefore considered consistent with previous observations that surface detectability of GGE activity declines during prolonged dry conditions.

Monitoring on 23 February 2026 also recorded no gurgles. By early March 2026, a single gurgle was detected during monitoring, indicating that some limited activity was occurring as soil moisture conditions improved slightly.

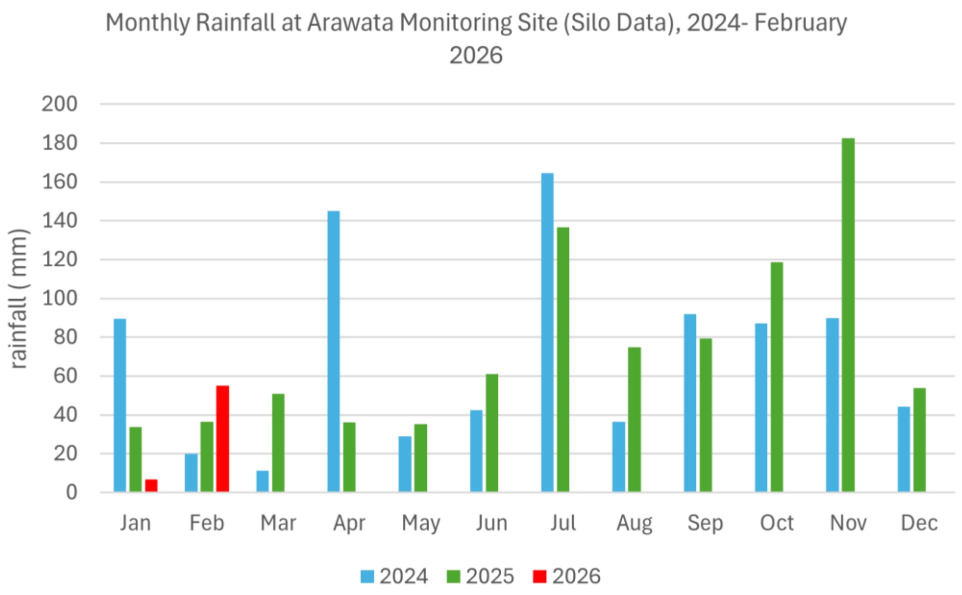
Table 3 Summary of GGE gurgle monitoring results at the Arawata hydrology monitoring site (2024–2026).

Monitoring Event	Date	Season	Number of Gurgles Detected	Notes
Baseline survey	May 2024	Winter	55	Survey undertaken across similar areas prior to transect monitoring
Monitoring 1	15 May 2025	Autumn	3	Dry conditions; very low rainfall preceding survey
Monitoring 2	16 Oct 2025	Spring	6	Slight increase following winter rainfall
Incidental observations	19 Nov 2025	Spring	16	Six gurgles recorded outside transects and ten around probe sites
Monitoring 3	15 Jan 2026	Summer	0	Extremely dry soil conditions
Monitoring 4	23 Feb 2026	Summer	0	Deeper soil moisture present but no surface gurgles
Monitoring 5	4 Mar 2026	Late summer/Autumn	1	Slight increase in soil moisture

Rainfall

Rainfall conditions during the summer monitoring period provide important context for interpreting the gurgle survey results. SILO rainfall data indicate that only 6.6 mm (compared with the average 10-year rainfall of 50.6 mm) was recorded in January 2026, representing extremely dry conditions at the start of the monitoring period. Rainfall increased during February 2026 (55.1 mm) which is above the 10-year average of 30.1mm (Figure 13). However, field observations during the February survey indicated that surface soils remained relatively dry and compacted. This suggests that rainfall had not yet fully recharged soil moisture conditions within the upper soil profile. Portable soil moisture probe measurements undertaken during the monitoring visits supported these observations indicating that while deeper sections of the soil profile retained moderate moisture, the upper soil layers, remained relatively dry. These conditions are likely to reduce the detectability of gurgling activity at the surface, even if GGE remain active at depth. Similar patterns were reported in the permanent soil moisture monitoring study by Aberton and Phillips (2026 see Section 3.2.8)

Figure 13. Monthly rainfall derived from the SILO Data Drill dataset for the grid cell corresponding to the Arawata monitoring site from January 2024 to February 2026.



Portable Soil Moisture Monitoring

In addition to the permanently installed hydrological probes, portable soil moisture measurements were undertaken using a MP406 Moisture Sensor to provide supplementary information on near-surface and sub-surface soil moisture conditions during summer.

The results are summarised in Table 4.

During the January 2026 monitoring event, extremely dry and compacted soils limited probe insertion to shallow depths (approximately 25–60 mm). Volumetric soil water (VSW) readings from this shallow layer ranged from approximately 10–18%, indicating very dry surface conditions.

To improve data quality for subsequent surveys, a portable earth auger was used to pre-drill narrow holes during the February 2026 monitoring event. This allowed soil moisture measurements to be obtained at depths of up to approximately 700 mm. Measurements were taken at the soil surface and at depths of approximately 100 mm, 350 mm and up to 700 mm where feasible. Each monitoring location comprised a single hole, drilled with a 50mm soil-auger within 2.5m of a fixed monitoring station, to each depth where measurements were taken. The soil-augering process enabled observations of the soil being removed from the holes, including some changes in soil characteristics through the soil profile, such as moisture, texture and colour. Some of these observations correlated with variation in the soil moisture readings. For example, moist, mouldable blue-grey clay that stuck to the auger-bit where soil moisture was higher.

February 2026 monitoring recorded volumetric soil water values ranging from approximately 16–29% VSW within the upper soil layers and increasing to approximately 28–36% VSW below approximately 300 mm depth. These results demonstrate a clear vertical moisture gradient, with deeper soil layers retaining some moisture despite very dry surface conditions.

By early March 2026, soil moisture values across the profile ranged from approximately 23–35% VSW, indicating moderately moist conditions at depth. A single gurgle was detected during this survey, suggesting that GGE activity may increase once moisture conditions improve across the soil profile.

Additional Comparisons

Mount Worth State Park

A comparative assessment was undertaken at Mount Worth State Park on 20 January 2026, where GGE gurgle monitoring is being undertaken monthly by a volunteer Friends group. Numerous gurgles had been recorded at this site on 4 January 2026.

Although surface soils at Mount Worth were similarly dry to those recorded at the Arawata hydrology site (approximately 10–18% VSW at 100 mm depth), soil moisture increased with depth, with values of approximately 24–30% VSW recorded between 225 mm and 380 mm. These deeper soils were assessed as slightly moist to moist and coincided with continued detection of GGE gurgles during summer conditions.

This comparison suggests that continued GGE activity during dry periods may be strongly linked to the availability of deeper soil moisture reserves rather than surface conditions alone.

Moyarra Soak Site

A supplementary comparison was undertaken at a property at Moyarra where GGE activity has been recorded during summer months within a small, persistent groundwater-fed soak on a south-east facing slope. Soil moisture measurements undertaken on 4 March 2026 indicated higher moisture availability than at the Arawata hydrology site, particularly within the upper soil profile. Volumetric soil water (VSW) values ranged from approximately 19% to 41% across the measured profile to 600 mm depth, with moisture values generally between 27% and 41% at depths of 100–350 mm.

A gurgle was detected during this assessment, consistent with previous summer observations at the site (B. Brandon pers. comm. 2026). The soak site retains persistent near-surface moisture due to local groundwater discharge, in contrast to the hydrology monitoring site where the upper soil layers become extremely dry during extended summer periods.

Although these observations were not undertaken as part of a controlled experimental design, they provide useful information. Together, the Arawata monitoring results and the comparison sites (Mount Worth State Park and the Moyarra soak) suggest that while deeper soil moisture reserves may allow GGEs to persist during dry periods, surface and near-surface soil moisture likely plays an important role in triggering detectable gurgling activity.

Table 4 Summary of portable soil moisture probe measurements and associated gurgle detections during summer monitoring.

Site	Date	Gurgles detected	Max depth achieved	Soil moisture (VSW) summary	Interpretation
Arawata Site 1 Hydrology site	15 Jan 2026	0	~60 mm	Surface layer only (10–18% VSW); deeper moisture not measurable	Surface soils extremely dry; measurements reflect surface desiccation rather than deeper soil profile
Arawata Site 1 Hydrology site	23 Feb 2026	0	~700 mm	~16–29% VSW at 60–100 mm; increasing to ~28–36% below ~300 mm	Clear vertical moisture gradient; deeper moisture reserves present despite absence of surface gurgles
Arawata Site 1 Hydrology site	4 Mar 2026	1	~700 mm	23–35% VSW across profile; generally, ~30–34% through most depths	Soil moisture conditions broadly comparable to February with some moisture retained at depth
Mount Worth State Park	20 Jan 2026	Gurgles recorded 4 Jan	~380 mm	~19–21% at 100 mm; ~24–30% at 225–380 mm	Moisture increases with depth; consistent with continued activity during summer
Moyarra soak	4 Mar 2026	1	~600 mm	19–41% VSW across profile; generally, ~27–41% at 100–350 mm	Persistent near-surface moisture associated with groundwater seepage; higher moisture than hydrology site

3.2.8 Permanent Soil Moisture Monitoring Probes.

A permanent soil moisture monitoring program was undertaken at the site by Aberton and Phillips (2026) using installed probes to measure soil moisture conditions at multiple depths over time. The monitoring results indicate that soil moisture conditions vary substantially within the upper soil profile, with shallow layers responding rapidly to rainfall and drying events, while deeper soil layers retain more stable moisture conditions (Figure 14).

Key findings from the permanent monitoring include:

- Soil moisture shows strong seasonal variation, with highest moisture levels generally occurring during winter and spring and lower values recorded during late summer and early autumn.
- Shallow soil layers respond immediately to rainfall events but also dry relatively quickly during dry periods.
- Deeper soil layers maintain more stable moisture conditions and often retain moderate moisture even when surface soils are dry.
- Deeper soil layers require sustained or cumulative rainfall for deep infiltration rather than short, isolated events.
- A vertical moisture gradient is evident, with moisture generally increasing with depth within the soil profile.
- Short-term rainfall events do not necessarily result in immediate recharge of the upper soil profile where soils are compacted or dry.
- Temperature stability increases with depth
- Soil oxygen levels were strongly influenced by soil moisture conditions, with extended oxygen suppression occurring during periods of high rainfall and elevated soil moisture, particularly within the colony where drainage appeared more limited.

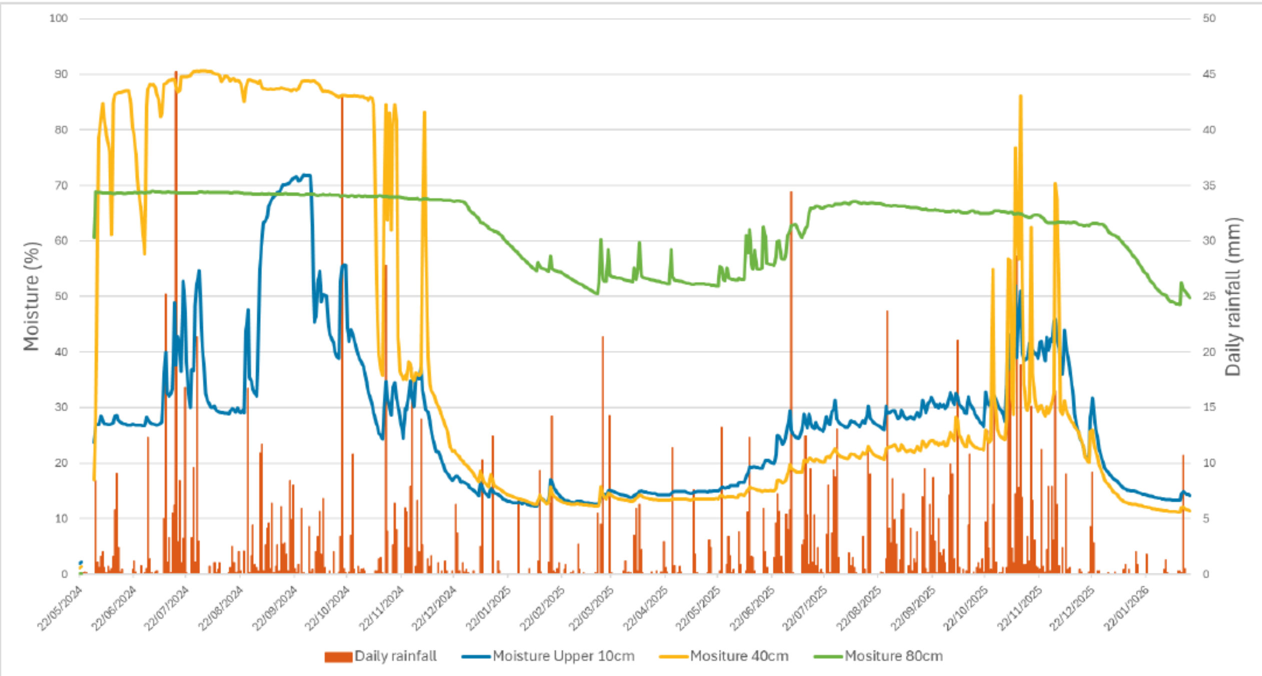
- Oxygen levels recovered and stabilised near atmospheric concentrations as soil moisture declined in 2025, indicating improved aeration following the wetter phase.

The monitoring showed that during dry summer periods the upper soil layers can become relatively dry even where deeper soil horizons remain moderately moist. This vertical moisture gradient suggests that suitable moisture conditions for GGEs may persist at depth despite the absence of surface indicators of activity.

These findings broadly align with the portable soil moisture probe measurements undertaken during the January–March monitoring, which also indicated relatively dry conditions within the upper soil layers while deeper sections of the soil profile retained moderate moisture. The portable probe measurements undertaken as part of this study were subject to several limitations, including variable access depth, soil compaction and difficulties in achieving consistent probe insertion across sampling events. Despite these constraints, the results showed similar trends to those observed in the permanent monitoring data.

Soil moisture data from Probe 4, located in a flat area above the GGE colony at monitoring Area 2 where no GGE were detected, showed a marked decline in moisture at depth during summer, with values falling below 35% (Aberton and Phillips 2026). In contrast to probes located within GGE habitat, this site did not retain higher moisture levels in deeper soil horizons during drier periods. The absence of GGE at this location, combined with reduced moisture retention at depth, suggests that the ability of soils to retain moisture within deeper horizons may be a key determinant of habitat suitability.

Figure 14. Soil moisture dynamics at three depths (10 cm, 40 cm and 80 cm) in relation to daily rainfall at the Arawata monitoring site (Probe 6), May 2024 – January 2026. Source Water Technology Aberton and Phillips 2026.



Monitoring at the revegetated site (Probe 8) indicated differences in soil moisture behaviour compared to adjacent pasture-dominated areas. Soil moisture levels at depth were generally lower during dry periods and showed reduced responsiveness to rainfall events. This pattern is likely associated with increased water uptake by establishing vegetation, particularly as root systems develop and extend through the soil profile.

Surface soil conditions remained broadly similar between revegetated and non-revegetated areas, reflecting the presence of groundcover vegetation at both sites. However, differences in deeper soil moisture suggest that vegetation type and structure may influence subsurface moisture availability within GGE habitat.

3.3 Site 2- Ranceby A

Due to landowner illness, one property was taken out of the project and replaced with Site 2 Ranceby A. As the initial landholder withdrew at the last minute, the property was selected as it was time efficient (the GGE colony was previously mapped in September 2022 and April 2023) and the landholder was known to be committed to on-ground works and GGE conservation.

Site history and land use:

The current landowners purchased the property in 2022, and it is presently leased with beef cattle being run by the lessee. The landowners are investigating options for building a house. While there is existing external fencing, there are no internal fences on the property.

3.3.1 GGE Site Assessment

Surveys confirmed that GGE colonies were widespread along both tributaries of Wilkur Creek (Figure 15, Photo 10). A single colony was identified in two areas of suitable habitat along the tributary flowing north–south through a steep, south-facing gully (referred to as Site 1). This site was fenced in 2023. The second tributary, flowing southwest to northeast across the property, supported multiple disjunct colonies (designated as Site 2).

A total of 25 individual GGE records were documented across the site, comprising:

- 21 gurgles
- 1 hatched egg cocoon
- fresh burrows

Of these, Site 2 accounted for 12 records, including 9 gurgles, 1 hatched egg cocoon, and 3 fresh burrows.

Site 2 was selected for fencing and revegetation in the current project due to its more manageable extent and alignment with available funding resources. GGE records at this site were distributed along approximately 510 metres of creek bank, with several colonies restricted to small patches of suitable habitat.

The creekline vegetation included remnant Eucalypt species, although the area was also infested with invasive species such as Willows (*Salix sp*.), Blackberry (*Rubus anglocandicans*), and Ragwort (*Senecio jacobaea*).

Figure 15 GGE colonies at Site 2 Ranceby A

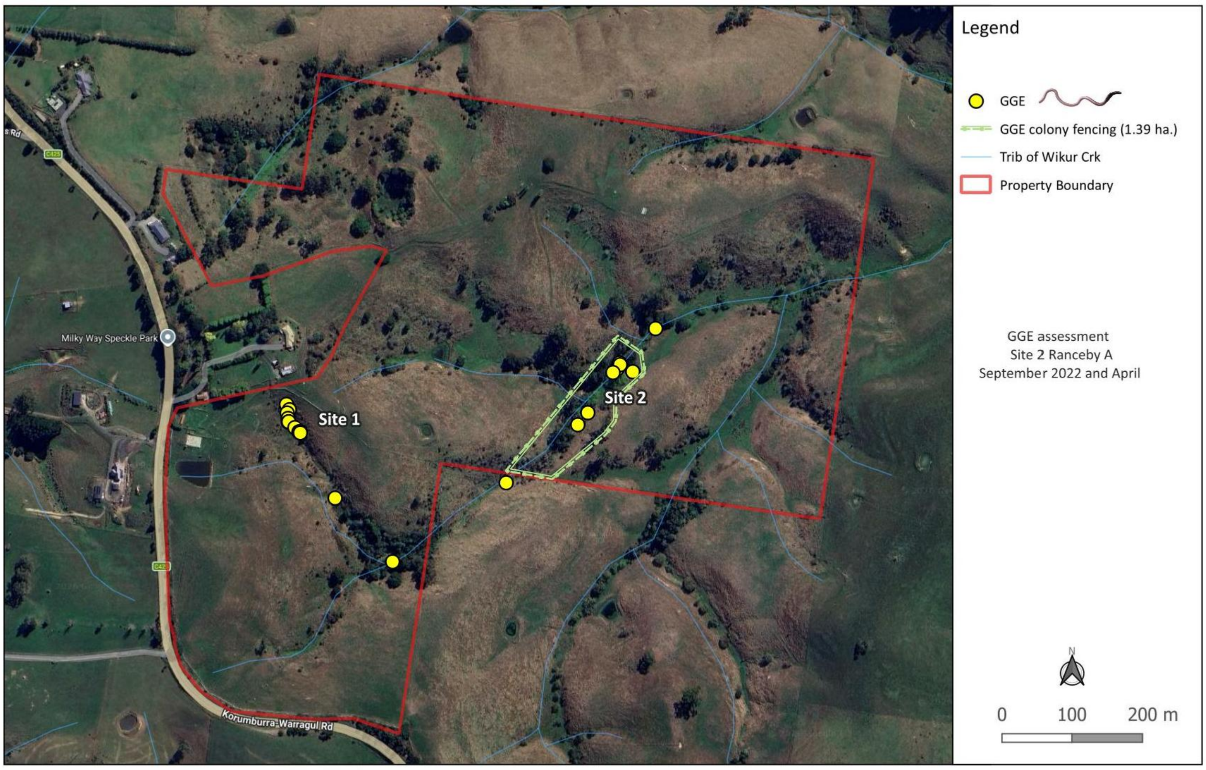


Photo 10 GGE habitat along lower tributary of Wilkur Creek

3.3.2 Vegetation Monitoring

This is the second quadrat to be established on this property. The first quadrat (MMIL1) was established in April 2023 as part of the previous ‘Enhanced Knowledge and Protection of the GGE’ project as part of the Federal Government’s Environment Restoration Fund-Threatened Species Strategy Action Plan- Priority Species Grants. It was then re-surveyed in September 2024 as part of the current ongoing vegetation monitoring project.

An 8 x 8m quadrat was established in May 2025 on a clay embankment 15m upslope from the creek, possibly a small, old landslip (MMIL2). The soil is a moist to dry clay loam but would be much wetter during the winter months. The entire GGE habitat site was not much larger than the quadrat with soils consisting of drier sandy loams in adjacent areas. Two GGE gurgles were heard just downslope at the bottom of the clay embankment. A large area has been fenced off and weeds such as blackberries, hawthorn bushes and willows have been treated. Revegetation has occurred outside the GGE habitat zone.

Blackwood (*Acacia melanoxylon*) was overhanging the site and the ground layer consisted of pasture grasses such as Yorkshire Fog (*Holcus lanatus*), Cocksfoot (*Dactylis glomerata*) and Kikuyu (*Cenchrus clandestinus*). Weedy herbs were also present and included Creeping Buttercup (*Ranunculus repens*), Self-heal (*Prunella vulgaris*), White Clover (*Trifolium repens*) and Fiddle Dock (*Rumex pulcher* subsp. *pulcher*).


Photo 11 MMIL2 quadrat site MMIL2 adjacent vegetation along the creek

3.4 Site 3- Kardella

Site history and land use

This property has been in the landholder's family for multiple generations, with the original large landholding subdivided over time and split up amongst extended family members. It is run as a beef farm. Some waterways have been fenced and revegetated for decades, with smaller gullies being fenced and planted in recent years.

3.4.1 GGE Assessment

A large, active colony of GGE was recorded across a south-east facing slope in the north- west corner of the property, above a gully that drains into a tributary of Coalition Creek (Figure 16, Photo 12). The colony extended approximately 50 metres across the slope and 20 metres upslope. A total of 12 individual records were documented, comprising nine gurgles and two fresh burrows. The area exhibited characteristics typical of GGE habitat, including undulating terrain, moist grey clay soils, and the presence of buttercups (*Ranunculus* spp.).

Figure 16 GGE colony at Site 3 Kardella

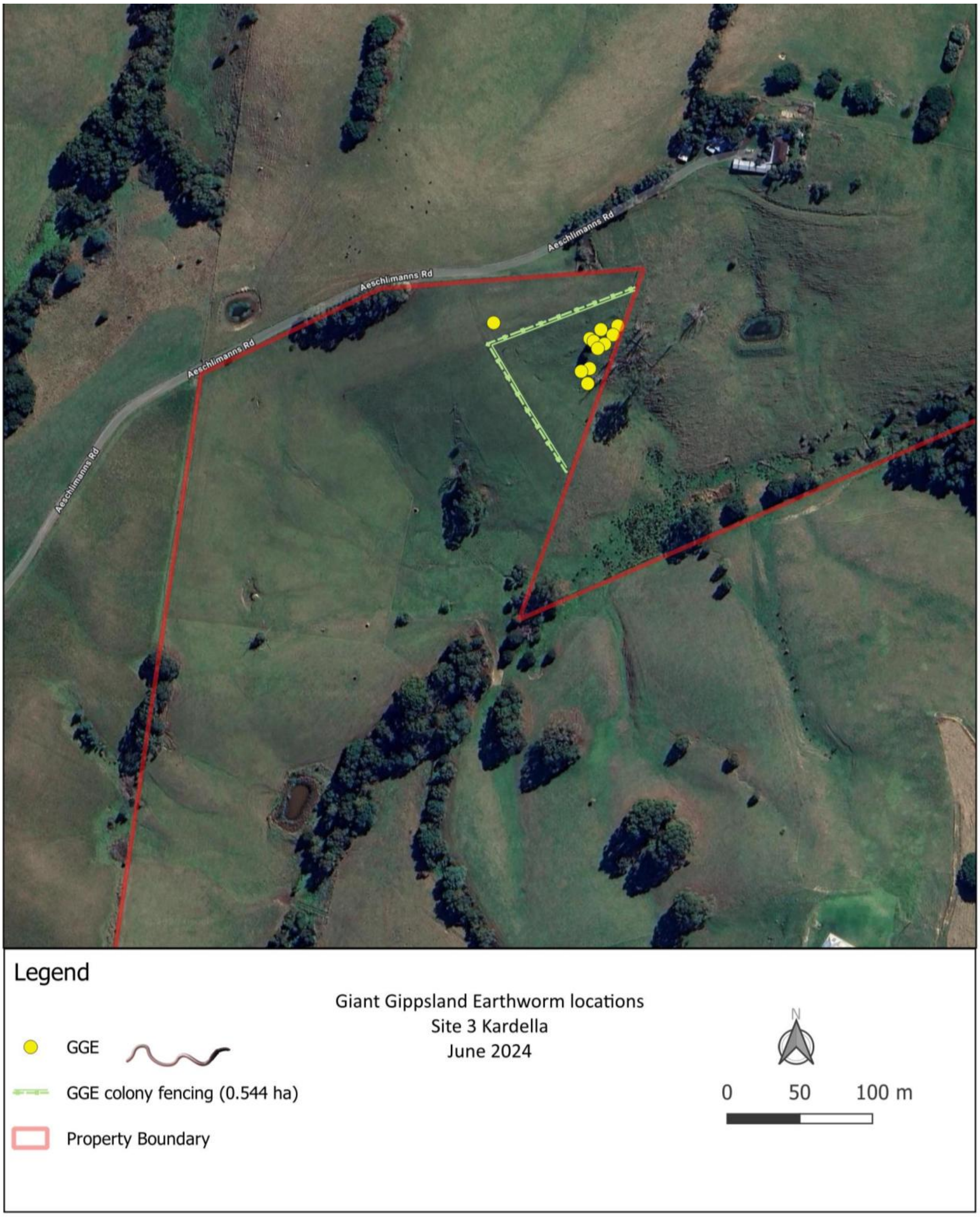


Photo 12 Overview landscape at Site 3 Kardella

Photo 13 GGE habitat at Site 3 Kardella showing sloping habitat with terracettes

3.4.2 Vegetation Monitoring

Two vegetation monitoring sites were established (AES1 and AES2).

AES1 quadrat site

ASE1 is a 5 x 5m quadrat established on a very wet lower slope approximately 3-4 metres upslope from the east-west creek running through the property. GGE gurgles were heard at the site. The general area was fenced and revegetated approximately 30 years ago, mainly with indigenous species although some non-native trees and shrubs are also present. Taller trees and shrubs are largely absent where GGE are located, likely due to the heavy clay soils and persistent moisture conditions associated with GGE habitat.

The quadrat is dominated by the weeds Creeping Buttercup (*Ranunculus repens*) and Blue Periwinkle (*Vinca major*). A number of Burrowing Crayfish chimneys were present. Upslope from the quadrat, indigenous trees and shrubs included Blackwood (*Acacia melanoxylon*), Sweet Pittosporum (*Pittosporum undulatum*), Silver Musk Daisy-bush (*Olearia argophylla*), Snowy Daisy-bush (*Olearia lirata*), Silver Wattle (*Acacia dealbata*) and Hazel Pomaderris (*Pomaderris aspera*). Taller eucalypts such as Manna Gum (*Eucalyptus viminalis* subsp. *viminalis*) were growing on the upper slope. Indigenous plants present included Prickly Currant-bush (*Coprosma quadrifida*), Tall Sedge (*Carex appressa*) and the fern, Tender Brake (*Pteris tremula*).

Photo 14 ASE1 Quadrat Site 3 Kardella

AES2 quadrat site

A 10 x 8 m quadrat was established on a pasture site to be fenced off and revegetated by the landowner as part of on-ground works for this project. GGE gurgles were heard within the quadrat and in the surrounding area. Cattle were grazing at the site when undertaking the survey but the fencing has since been completed. Soils were a moist, brown clay loam. The quadrat site was dominated by weedy grasses such as Cocksfoot (*Dactylis glomerata*) and Brown-top Bent (*Agrostis capillaris*), Weedy herbs present included Creeping Buttercup (*Ranunculus repens*), Ribwort (*Plantago lanceolata*) and Self-heal (*Prunella vulgaris*) and the indigenous herb, Small Loosestrife (*Lythrum hyssopifolia*) also occurred in the site.

Areas more than 10m from the buffer area of the GGE site within the newly fenced area are being revegetated with graminoids and small shrubs according to the GGE Guidelines for planting in revegetation areas.

Photo 15 AES2 Quadrat AES2: General view looking downslope to AES2 -Site 3, Kardella

3.4.4 On-ground Actions

On-ground actions undertaken included:

- 210m of fencing to exclude stock
- Planting 800 EVC-appropriate local indigenous seedlings. A tussock/sedges/small shrub mix was used for areas within 40m of the GGE colonies, with a standard EVC mix used for the north-western corner of the site (furthest from the GGEs).

3.5 Site 4 Ranceby B

Site history and land use

This property has been owned by the current owner for a few years and is currently used for running beef cattle. Under previous ownership the land was poorly managed and has become heavily infested with extensive weeds, particularly along the creekline where very large hawthorns and dense blackberry thickets are present.

3.5.1 GGE Assessment

Two large colonies of GGEs were identified at the site: one occupying a south-facing slope and the other situated on lower ground adjacent to the creekbank (Figure 16, Photo 17). The slope colony extended approximately 30 metres across the slope and 20 metres downslope, while the creekside colony covered a linear area of approximately 100 metres along the creek, extending up to 20 metres from the creek bank. A total of 31 individual records were documented across both colonies, comprising 23 gurgles, seven old burrows, and one egg cocoon.

Figure 17 GGE colony and fencing at Site 4 Ranceby B

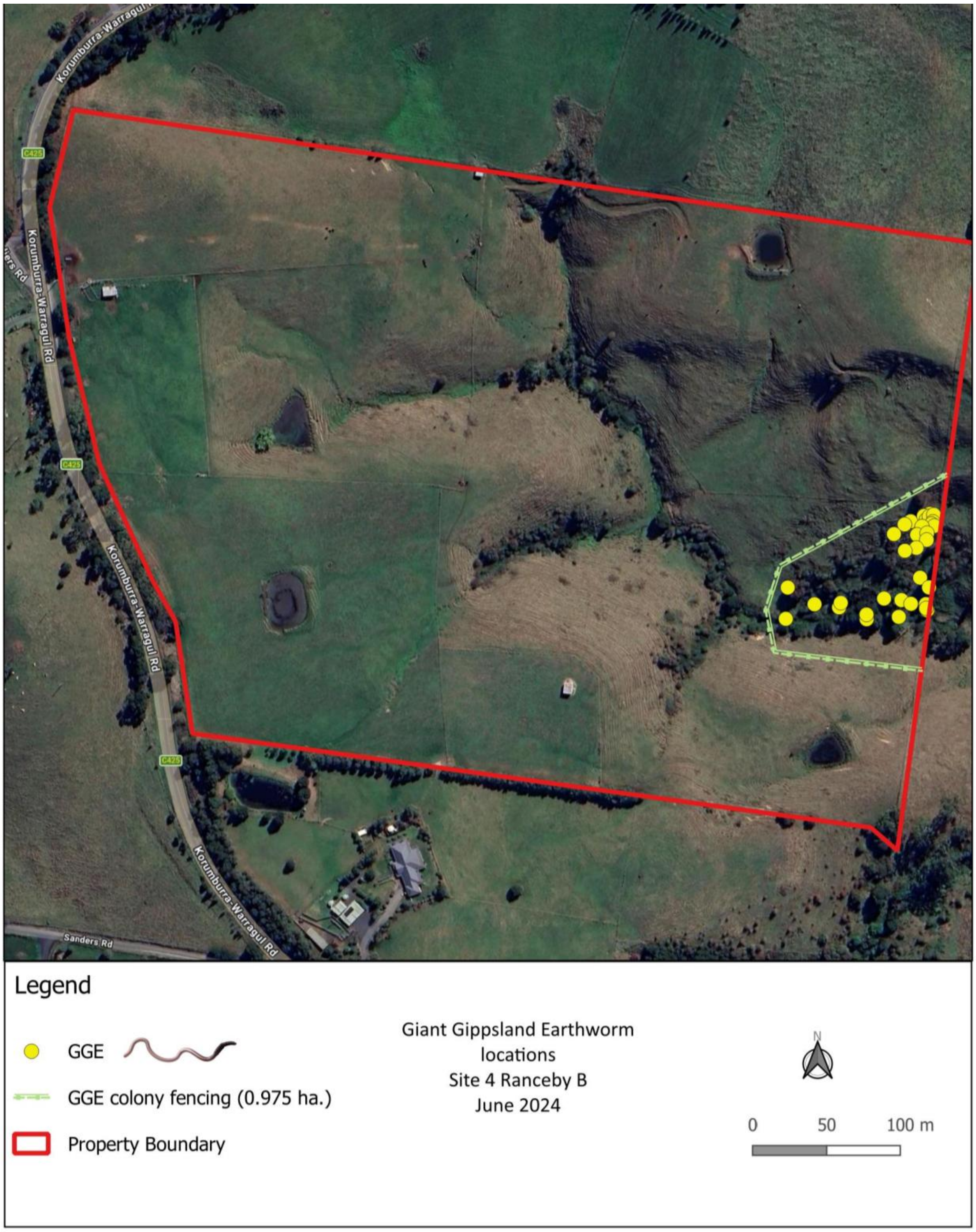


Photo 16 GGE habitat at Site 4, Ranceby B showing GGE habitat and burrows

3.5.2 Vegetation Monitoring

Two quadrats were established at this property in different topographic situations within GGE habitat (GAL1 and GAL2).

GAL1 Quadrat site

This 10 x 10m quadrat was established in September 2024 towards the base of an old partial landslip on a steep, terraced slope (Photo 17). Numerous GGE gurgles were heard both within the site and in the adjacent area of wet, grey clay soils. Cattle grazing occurred on the site but it has since been fenced and revegetated as part of this grant.

As to be expected on pastured land, non-native pasture grasses and herbs such as cocksfoot (*Dactylis glomerata*), Brown-top Bent (*Agrostis capillaris)* and Cover (*Trifolium* species) dominated the site with the only indigenous species being scattered Bidgee-widgee (*Acaena novae-zelandiae*). There were some blackberry (*Rubus anglocandicans*) patches and a Hawthorn (*Crataegus monogyna*) just outside the quadrat.

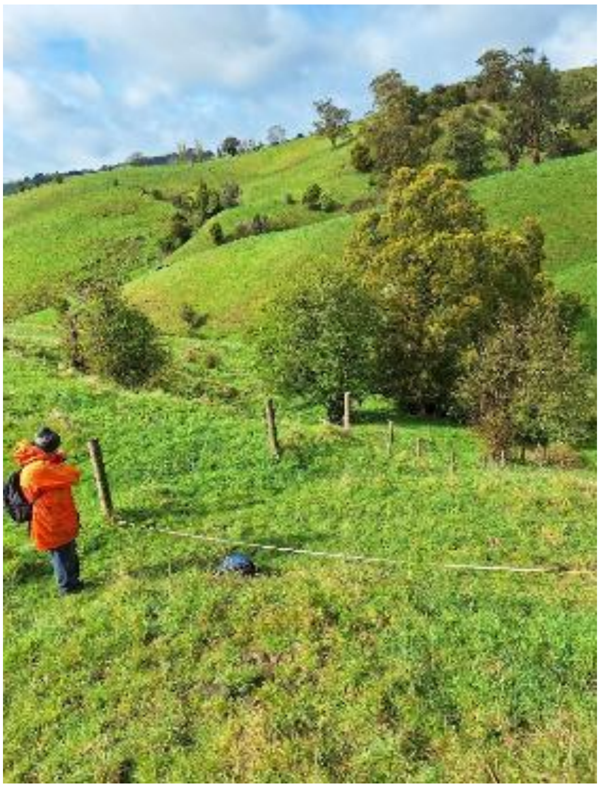


Photo 17 Soil Monitoring Site GAL1 at site 4 Ranceby B

GAL2 Quadrat Site

The second quadrat established on this property was downslope of GAL1 on a southerly aspect and adjacent to the creek terrace. Numerous GGE gurgles were heard within the quadrat, upslope and along the creek terrace. Soils were similar to the GAL1 site - wet grey clays. Infestations of blackberries lined the creek, together with numerous hawthorn trees. These infestations have now been treated as part of funding for this project and partial areas outside the GGE zone have now been revegetated.

Once again, pasture grasses such as Cocksfoot (*Dactylis glomerata*), Brown-top Bent (*Agrostis capillaris)* and Yorkshire Fog (*Holcus lanatus*) dominated the site. Creeping Buttercup (*Ranunculus repens*) was also present, together with a number of other weedy herbs. No indigenous plant species were present. The nearest indigenous species were along the riparian zone and included Blackwood (*Acacia melanoxylon*), Tree Everlasting (*Ozothamnus ferrugineus*), Kangaroo Apple (*Solanum aviculare*), Soft Tree-fern (*Cyathea australis*), and Common Ground-fern (*Calochlaena dubia*).


On-ground actions undertaken included:

- 290m of fencing to exclude stock.
- Planting 1500 EVC-appropriate local indigenous seedlings. A tussock/sedges/small shrub mix was used for areas within 40m of the GGE colonies, with a standard EVC mix used for the area across the other side of the gully. The seedlings were planted by the landholder and volunteers at a community planting day.
- Weed control undertaken over 4 days by a 2-person professional works crew, controlling blackberries, hawthorn and boxthorn.

4 DISCUSSION

4.1 Soil Moisture Dynamics in GGE Habitat

Long-term soil hydrology monitoring undertaken at the Arawata site indicates that soil moisture conditions vary substantially with depth and season within GGE habitat soils. Monitoring data from permanently installed probes show that shallow soil layers respond rapidly to rainfall events but also dry quickly during extended dry periods. In contrast, deeper soil layers respond more slowly to rainfall recharge and retain moisture for longer periods.

Soil hydrology monitoring undertaken as part of this study demonstrates that both soil moisture and temperature exhibit strong depth-related gradients. Surface soils (approximately 10 cm) respond rapidly to rainfall and atmospheric conditions and are characterised by high variability and rapid drying, whereas deeper soils (40–80 cm) show significantly greater stability, with moisture levels influenced by cumulative rainfall and temperature fluctuations dampened by the thermal buffering capacity of the soil profile.

These findings provide a mechanistic explanation for the strong association of GGE with deep, clay-rich soils. Deep clay profiles maintain more stable moisture and temperature conditions, reducing exposure to short-term climatic extremes and providing a reliable and buffered subsoil environment. In contrast, shallow soils, particularly on north-facing or steep slopes where shallow soil profiles and increased solar exposure promote rapid drying, are subject to greater temperature variability and limited moisture retention, thereby reducing their suitability for sustaining GGE populations.

This depth-related buffering effect is likely a key determinant of habitat suitability, as it enables GGE to persist within a relatively stable subsurface environment despite highly variable surface conditions. The absence of such buffering in shallow or freely drained soils is likely to constrain burrow stability, moisture availability and overall habitat suitability. Importantly, this vertical stratification of soil moisture indicates that surface conditions alone are not a reliable indicator of habitat suitability for GGE.

Water availability in soil plays an important role in regulating earthworm activity (Kretzschmar and Bruchou, 1991). Adequate soil moisture is required to support physiological processes including respiration and metabolic function and also facilitates movement through soil and burrow systems. Earthworms rely on moist soil conditions to maintain these processes, with water obtained through both dermal exchange and ingestion of moist soil. As a result, deeper soils are likely to provide important refuge conditions for GGE during extended dry periods.

Unlike some earthworm species that aestivate during hot or dry conditions, GGE remain active within the soil profile and rely on access to suitable moisture conditions at depth. The availability of deeper, moist soil horizons is therefore likely critical for persistence during extended dry periods.

Portable soil moisture probe measurements, although not rigorous, were undertaken during the summer monitoring period and support these observations. Measurements indicated the presence of a vertical soil moisture gradient within the soil profile, with relatively dry surface soils but moderate moisture levels retained at depth. These findings suggest that suitable moisture conditions may persist within deeper soil horizons even during periods when surface soils appear dry.

Soil oxygen data indicate that periods of high soil moisture and saturation can result in reduced oxygen availability within the soil profile. Prolonged oxygen suppression was observed during wetter periods, particularly within GGE habitat areas where drainage appeared more limited.

These findings suggest that, in addition to avoiding excessively dry conditions, GGE habitat also requires sufficient soil aeration. Excessively wet soils can flood burrows, forcing earthworms closer to the surface or out of their burrows. This highlights the importance of maintaining a balance between soil moisture and oxygen availability, as prolonged saturation may limit suitable habitat conditions despite the presence of adequate moisture.

4.2 Relationship Between Soil Moisture and GGE Activity

Gurgle monitoring undertaken during the study period suggests a relationship between soil moisture conditions and the detectability of GGE activity. Higher numbers of gurgle detections were recorded during periods when soil moisture conditions were elevated, particularly during winter and spring monitoring events. Conversely, few or no gurgles were detected during extended dry periods, including summer 2026. This was also the case even in winter (e.g. May 2025) when the area was experiencing drought-like conditions.

In contrast, probe data from the location outside confirmed GGE habitat (Probe 4), suggest that some areas may not retain sufficient subsoil moisture during dry periods to provide effective refuge for GGE. At this location, soil moisture levels at depth declined substantially during summer, falling below 35% (Aberton and Phillips 2026). Unlike probes located within GGE habitat, this site did not retain higher moisture levels in deeper soil horizons during drier periods. This suggests that the availability of deeper, moisture-retentive soil layers may be an important factor influencing the presence and persistence of GGE.

Earthworm responses to soil moisture and temperature vary among ecological groups. Earthworms have been classified into ecological groups based on their depth distribution, morphology and functional behaviour within the soil profile (Lee 1959; Bouché 1977; Perel 1977). These classifications recognise species occupying surface litter layers, topsoil horizons and deeper subsoil environments (Figure 18).

The GGE is best described as a subsoil species (hypoendogeic), occupying deeper soil horizons and constructing extensive, permanent burrow systems. The species possesses exceptionally thick anterior septa (Spencer 1888; Van Praagh 1994), a morphological characteristic likely to facilitate movement through dense clay subsoils and enable vertical migration within the soil profile. This trait appears to be common among large-bodied earthworm species adapted to deep burrowing.

Available observations indicate that GGE does not enter diapause or aestivation during dry conditions (Van Praagh 1994). Instead, individuals respond to changes in soil moisture through vertical movement within the soil profile. Excavations undertaken by Van Praagh (1994) at Loch, South Gippsland, recorded marked seasonal differences in depth distribution, with adults occurring at depths exceeding 1 m during late summer, depending on local soil moisture conditions. In contrast, where soils remain moist throughout the year, vertical movement may be less pronounced, with individuals remaining closer to the surface, such as at the Moyarra site where worms occupied the margins of a persistent soak.

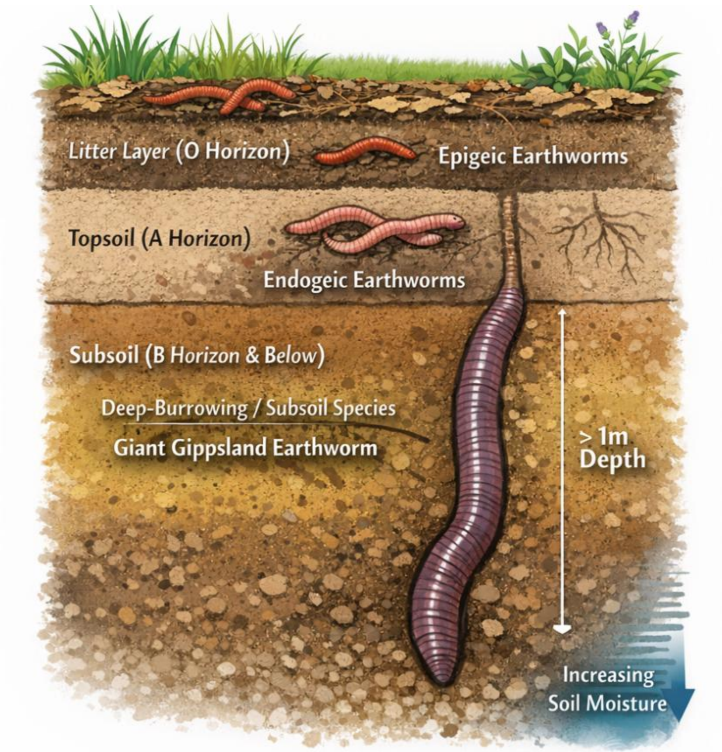
Further work on population structure (Van Praagh 1996) recorded worms at an average depth of 37.2 cm during summer under relatively mild conditions and in association with sustained soil moisture availability. These observations reinforce that GGE track soil moisture within the profile rather than entering a dormant state, remaining active at depth even under drier conditions.

This behaviour is consistent with that of large, deep-burrowing earthworms, which typically avoid desiccation by retreating to deeper, moisture-retentive soil layers rather than aestivating. In contrast to smaller, surface-dwelling species that may form mucus chambers and enter metabolic shutdown during dry periods, large-bodied species are less suited to this strategy and instead rely on access to buffered subsoil environments where moisture conditions remain relatively stable

These behavioural patterns suggest that seasonal drying of the upper soil profile results in GGE retreating deeper within their burrow systems, where soil moisture is maintained. As soil moisture increases following sustained rainfall, individuals may move closer to the surface, where their activity becomes detectable through the characteristic gurgling sound associated with movement through water-filled burrows.

While the present study does not establish a specific soil moisture threshold for persistence, prolonged drying of both surface and deeper soil horizon is likely to reduce habitat suitability and increase vulnerability to drought and climate change. Prolonged restriction of GGE to deeper soil layers during dry periods may also influence feeding and reproduction. As organic matter is generally concentrated in near-surface soils, reduced access to these layers may limit food availability and energy intake, with potential implications for growth and reproductive output. Observations from Probe 6 (see Figure 15), which recorded extended periods of low soil moisture in the upper and mid soil profile, further highlight the potential importance of deeper soil layers as drought refuge. Whether GGE can persist under such conditions by retreating to greater depths remains uncertain and represents an important area for future research.

Figure 18 Ecological classification of earthworms



4.3 GGE Habitat

Surveys undertaken during the project recorded a total of 111 GGE records across four properties. Most colonies were associated with steep south- or southeast-facing slopes, commonly characterised by terracettes and lower drainage lines with moist clay soils. These conditions are representative of previously documented habitat preferences for the species.

South-facing slopes typically receive reduced solar radiation and therefore tend to retain higher soil moisture levels. Similarly, terracettes and lower slope positions can concentrate subsurface moisture and slow drainage, contributing to the maintenance of suitable soil moisture conditions within the clay subsoils occupied by GGE.

These habitat characteristics are consistent with the hydrological monitoring results from the present study, which indicate that deeper clay soils within these landscape positions are able to retain moisture for extended periods even when surface soils become dry. Such conditions are likely to provide important refugia for GGE during dry periods.

4.4 Vegetation Condition and Soil Moisture

Vegetation monitoring undertaken during the project provided additional insight into factors influencing soil moisture conditions within GGE. Observations across monitoring sites indicate that vegetation structure can influence soil moisture dynamics.

In areas where the vegetation was sparse and mainly consisted of grasses or sedges, the moisture levels found in the upper soil layers tended to align with the typical habitat conditions associated with GGE. In contrast, areas with dense vegetation or woody weed infestation tended to exhibit drier surface soils. These patterns are likely related to increased evapotranspiration and root water uptake associated with denser vegetation cover (higher biomass).

Preliminary soil moisture monitoring data suggest that baseline levels of approximately 70% may represent favourable conditions for GGE habitat. Conditions above approximately 80% may indicate excessively wet or saturated soils, while conditions below approximately 40% appear too dry to sustain suitable habitat conditions.

More specifically, observations from the permanent soil moisture monitoring indicate that the most consistent gurgle activity occurs where soil moisture is within the range of approximately 60–80% at depths between 40 cm and 80 cm, with a narrower range of approximately 60–70% observed at 80 cm depth. These ranges are most strongly associated with detectable earthworm activity and may vary depending on life stage, behaviour and position within the soil profile, including conditions associated with cocoon development in shallower soils.

Although these thresholds remain preliminary and are based on a limited dataset, they provide an important refinement of the soil moisture conditions associated with active GGE habitat and highlight the significance of deeper, stable moisture conditions within the soil profile.

Data from the revegetated monitoring site (probe 8) indicate that, during the early stages of vegetation establishment, soil moisture, particularly at depth, may decline as vegetation develops. This is likely due to increased evapotranspiration and the expansion of root systems into deeper soil horizons. These observations are consistent with long-term field experience indicating that GGE are rarely found beneath dense vegetation where soils become significantly drier. This supports the contention that GGE habitat occurring under pasture should not be revegetated with dense, woody vegetation. Instead, vegetation management should aim to maintain relatively open structures that support infiltration and minimise excessive water uptake.

These findings reinforce existing habitat management guidelines that recommend maintaining relatively open vegetation structures within GGE habitat areas, typically dominated by grasses, sedges or low groundcover species https://www.giantearthworm.org.au/sitefiles/fact-sheet2-July-2023.pdf. Maintaining these vegetation structures may assist in sustaining suitable soil moisture conditions while also protecting soil structure and reducing erosion.

4.5 Habitat Management and Landholder Engagement

Over the course of the project, 4 high-priority earthworm colonies were placed under active conservation management through fencing, revegetation, and targeted weed control. Site specific management plans were developed by Landcare in consultation with landholders.

These actions contributed to the long-term conservation of GGE populations by reducing trampling and pugging and compaction associated with cattle access. Excluding stock from colony areas and controlling weed invasion helps maintain vegetation structures that support suitable soil moisture conditions.

The engagement with landowners provided valuable opportunities for sharing of knowledge and educational opportunity. This was facilitated through building relationships with landowners, field visits, public talks, website content and the production a Fact Sheet Case Study on Regenerative Grazing at Moyarra Pastoral Company run by Burke Brandon (https://drift.media/interactive/gge_hydrology/index.htm)

A case study developed in collaboration with landholder Burke Brandon demonstrates how GGE conservation can be successfully integrated into farm management. Following the exposure of GGE during a landslip on his property, confirming their presence, Burke implemented a range of regenerative agriculture management practices to protect colonies. These include excluding stock from colony areas, incorporating colonies into remnant vegetation protection zones and revegetated areas, and protecting adjacent waterways.

Additional regenerative agriculture management practices adopted on the property include avoiding excavation and soil disturbance such as ploughing, deep ripping and scalping within colony areas, minimising pesticide use, and removing stock from rotational grazing during wet periods to prevent soil damage.

This case study demonstrates that simple, practical regenerative management practices can be integrated into productive agricultural landscapes while providing effective protection for GGE colonies. These outcomes also highlight the importance of community engagement and landholder participation in achieving broader conservation of the GGE.

4.6 Implications for Drought and Climate Variability

The summer monitoring period occurred during relatively dry conditions, particularly during January 2026 when rainfall was well below the long-term average. During this period surface soils within the monitoring areas were extremely dry and hardened, and no gurgle detections were recorded during two monitoring events. However, portable soil moisture probe measurements confirmed that deeper soil layers retained moderate moisture levels. Permanent soil moisture data also showed that while moisture levels at 10 and 40 cm fluctuate in response to rainfall, deeper layers (approximately 80 cm) remained relatively stable, generally around 65–70% and declining to around 50% during the driest period.

These observations suggest that the persistence of GGE populations during extended dry periods may depend on the availability of deeper soil moisture reserves within clay subsoils, in turn reliant on sustained rainfall events. The vertical soil moisture gradients observed during monitoring indicate that deeper soil horizons may retain biologically available moisture even when upper soil layers become dry.

Given that the species does not undergo aestivation or diapause, seasonal drying of the upper soil profile is likely to result in vertical movement within burrow systems. Individuals may retreat to deeper soil layers where moisture conditions remain suitable, returning closer to the surface when soil moisture increases following rainfall events.

These findings highlight the importance of maintaining natural hydrological processes within GGE habitat areas. Disturbances that alter drainage patterns, reduce soil moisture recharge, or increase soil drying may reduce the availability of suitable habitat conditions. Maintaining landscape features that support soil moisture retention, including natural drainage lines and seepage areas, at the property and catchment level is therefore likely to be important for supporting the long-term conservation of GGE populations under increasing climatic variability.

5 RECOMMENDATIONS

5.1 Future Hydrological Monitoring and Research

The pilot hydrological study has been instrumental in advancing understanding of the hydrological requirements of the GGE, a factor critical to the species' survival. This is particularly important given the increasing pressures from urban development, forestry and carbon-capture initiatives, agricultural practices, and climate change.

As this study represents a pilot investigation, it is recommended that the hydrological monitoring program be expanded to include:

Expansion of Monitoring Sites

In light of the substantial number of GGE records documented at Sites 2, 3 and 4 during surveys undertaken in September 2022, April 2023 and June 2024, it is recommended that these sites be revisited for future monitoring. This would enable assessment of whether GGE populations have persisted following the dry conditions experienced in 2025, and provide an opportunity to better link site-specific observations with the hydrological patterns identified in the Arawata Site 1 monitoring program.

- Establish additional hydrological monitoring sites across a broader range of habitat types, including creek banks, terraces and lower slope drainage lines.
- Include monitoring across a range of land use types, such as farmland, revegetated areas and peri-urban landscapes.
- Investigate soil hydrology across different catchments and landscape forms, including the rolling hills and flatter landscapes around Warragul as well as the steeper terrain of the Strzelecki Ranges.

Improved hydrological monitoring

- Continue long-term monitoring at the existing Arawata monitoring site using permanent soil moisture probes
- Install soil moisture probes capable of measuring to greater depths (up to 2 m) to capture variation across the full soil profile.
- Include water table and groundwater monitoring to better understand the relationship between soil moisture dynamics and local groundwater conditions
- Undertake long-term monitoring to capture seasonal responses and inter-annual climatic variability.

Hydrological processes and modelling

- Undertake hydrological modelling to improve understanding of catchment-scale influences on soil moisture conditions within GGE habitat.
- Combine hydrological monitoring with soil mapping to better understand the relationship between soil type, texture and suitable GGE habitat conditions.

Habitat management and restoration

- Expand monitoring within revegetated sites to include different vegetation ages and species assemblages in order to better understand the influence of revegetation on soil moisture dynamics in GGE habitat.
- Improve habitat mapping and predictive models using soil moisture monitoring data integrated with landscape datasets such as LiDAR. High-resolution LiDAR can assist in identifying fine-scale landform

features including terracettes, slope breaks and drainage pathways that influence soil moisture distribution and are frequently associated with GGE colonies.

- Integrate soil hydrology monitoring with ongoing GGE survey methods such as gurgle detection and habitat assessments. Linking soil moisture data with ecological observations will improve understanding of how hydrological conditions influence earthworm activity, detectability and habitat suitability, and will support the development of improved monitoring and habitat prediction models.
- Investigate the potential for passive acoustic soil monitoring to detect characteristic earthworm sounds within burrow systems. Acoustic sensors may be capable of recording the distinctive gurgling sounds or muscle movement through the soil produced by GGE, providing a non-invasive method that could complement traditional gurgle detection surveys and improve monitoring of earthworm activity over extended periods.

5.2 Vegetation Management and Revegetation

Vegetation management within GGE habitat should be carefully designed to maintain suitable soil moisture conditions, particularly within deeper soil horizons where GGE are most likely to persist during dry periods.

Monitoring results from this study indicate that vegetation structure can influence soil moisture dynamics. In particular, dense or woody vegetation may increase evapotranspiration and reduce soil moisture availability, including at depth.

Revegetation within GGE habitat should therefore prioritise open vegetation structures dominated by grasses, sedges and low groundcover species. These vegetation types promote rainfall infiltration while limiting excessive water uptake and maintaining stable soil moisture conditions.

Dense woody planting, including trees and large shrubs, should be avoided within and immediately adjacent to GGE habitat, particularly in areas supporting known or potential colonies. Such plantings may contribute to drying of the soil profile and reduce habitat suitability over time.

In some cases, retention of existing pasture or lightly vegetated conditions may be more appropriate than intensive revegetation, where these conditions support suitable soil moisture regimes.

Where revegetation is required for erosion control or land stabilisation, planting design should minimise water demand and avoid continuous dense cover. Zonal planting approaches may be applied, with low water-use species and open structures maintained closest to GGE habitat.

Overall, revegetation should be designed to support infiltration and maintain stable subsurface moisture conditions, rather than maximise vegetation density or canopy cover.

Detailed revegetation guidance, including species selection and planting design, is provided in the GGE Habitat Planting Guidelines (Fact Sheet 2).

6 COMMUNICATIONS

Project outputs including a downloadable Case Study document, and a video of the hydrology study have been made available through the GGE website (https://www.giantearthworm.org.au), as well as through the Bass Coast Landcare Network (BCLN) and South Gippsland Landcare Network (SGLN) websites and other electronic platforms.

A community field day was held to improve capacity within the local agricultural community to identify and manage GGE habitat on their properties. This event provided information on habitat identification, soil hydrology and practical management approaches that support the protection of GGE colonies.

An additional field day targeting farmers was undertaken as part of the case study component of the project. This event demonstrated regenerative agriculture and grazing management practices within GGE habitat and provided practical guidance to landholders on managing pastures and livestock to reduce soil disturbance, pugging and protect soil structure within colony areas.

Three community planting days were also held as part of the project to support habitat restoration activities and increase community participation in conservation actions.

A summary of the results of the soil hydrology pilot study and broader project findings will also be disseminated through a range of communication platforms including websites, enewsletters and social medial platforms, to support knowledge sharing and community awareness of GGE conservation

7 TRADITIONAL CUSTODIAN ENGAGEMENT

The project included engagement with Traditional Custodians through training activities for the Bunurong Land Council Aboriginal Corporation (BLCAC) Balirt Biik (Strong Country) Eastern Team. Training focused on identifying GGE habitat and understanding appropriate land management practices that support the protection of earthworm colonies.

The aim of these activities was to support knowledge sharing and collaboration, integrating contemporary conservation approaches with Traditional knowledge and land management practices.

8 COMMUNITY ENGAGEMENT

Engagement with private landowners has been a key component of the project and represents an important outcome for the long-term conservation of the GGE. Establishing trusting partnerships between landowners and the project team provides a strong foundation for ongoing habitat protection and improved land management practices.

Landowners directly involved in on-ground works signed a 10-year landholder agreement which documented on-ground works to be undertaken, that cattle would be excluded from the site, and that weed control would be maintained for a minimum ten-year period.

9 CONCLUSIONS

This project has contributed to improved understanding of GGE habitat within the south-western Strzelecki Ranges through targeted habitat assessments, hydrological monitoring and vegetation observations across four sites. Field investigations confirmed the presence of active earthworm colonies and highlighted the importance of moist lower slopes and drainage lines with clay-rich soils.

Hydrological monitoring and portable soil moisture probe measurements indicated that while surface soils may become dry during summer periods, deeper soil layers generally retain moisture. These deeper moisture reserves are likely critical for maintaining long-term persistence of colonies. The findings highlight that GGE habitat is defined not only by the presence of moisture, but by the stability and persistence of subsurface moisture conditions over time. Monitoring also indicates that deep soil moisture recharge is driven by sustained rainfall rather than short-term rainfall events, and that suitable habitat requires a balance between soil moisture and adequate soil aeration.

Vegetation monitoring demonstrated that GGE habitat occurs across a range of vegetation types including grazed pasture, remnant vegetation and revegetated areas. However, vegetation structure was shown to influence soil moisture dynamics, with dense vegetation associated with increased evapotranspiration and reduced soil moisture availability, particularly at depth. Landcare actions undertaken as part of the project have begun to address weed invasion and support habitat condition through revegetation and site management.

The results of this project contribute to a growing dataset of GGE habitat distribution and the environmental conditions required for this species. Continued monitoring of soil moisture, vegetation condition and earthworm activity will assist in refining conservation management approaches and supporting long-term protection of this threatened invertebrate under increasing climatic variability.

10 REFERENCES

Aberton, M. and Phillips, S. 2026 Threat Mitigation and Soil Hydrology for the Giant Gippsland Earthworm- Soil Hydrology Monitoring of Giant Gippsland Earthworm Habitat. Water Technology. April 2026

Bureau of Meteorology (BOM) (2025). *Climate Data Online – Monthly Rainfall, Station 085045 Korumburra, Victoria.* Commonwealth of Australia. Available at: http://www.bom.gov.au/climate/data (accessed October 2025).

Eriksen-Hamel N.S., Whalen JK (2006) Growth rates of *Aporrectodea caliginosa* (Oligochaetae: Lumbricidae) as influenced by soil temperature and moisture in disturbed and undisturbed soil columns. *Pedobiologia 50: 207–215.*

Gergs A., Rakel K., Bussen D., Capowiez Y., Ernst G., Roeben V.. Integrating earthworm movement and life history through dynamic energy budgets. *Conserv Physiol*. 2022 Jun 27;10(1)

Kretzschmar A (1991) Burrowing ability of the earthworm *Aporrectodea longa* limited by soil compaction and water potential. *Biol Fertil Soils* 11: 48–51.

Kretzschmar A., Bruchou C. (1991) Weight response to the soil water potential of the earthworm *Aporrectodea longa*. *Biol Fertil Soils* 12: 209–212

SILO (2026). SILO Data Drill. Long-term climate data for Australia. Queensland Government Department of Environment and Science. Available at: https://www.longpaddock.qld.gov.au/silo/

Oates, A., 2026 Vegetation Monitoring Report for 'Threat mitigation and soil hydrology for the Giant Gippsland Earthworm Project. Oates Environmental Consulting

Perreault J.M., Whalen J.K. (2006) Earthworm burrowing in laboratory microcosms as influenced by soil temperature and moisture. *Pedobiologia 5*0: 397–40

Victorian Resources Online (VRO) – Agriculture Victoria. 2023. *Strzelecki Soil Association.* https://vro.agriculture.vic.gov.au/dpi/vro/vrosite.nsf/pages/soil_strzelecki

Van Praagh, B.D. (1992). *The biology and conservation of the Giant Gippsland Earthworm Megascolides australis McCoy, 1878.* Soil Biology and Biochemistry, 24(12), 1363–1367

Van Praagh, B.D. (1994). *The biology and conservation of the Giant Gippsland Earthworm Megascolides australis McCoy (Oligochaeta: Megascolecidae).* PhD thesis, La Trobe University, Bundoora, Victoria, Australia.

Van Praagh, B. D. (1996). Reproductive biology of *Megascolides australis* McCoy (Oligochaeta: Megascolecidae). *Australian Journal of Zoology* 43:489-507.