



PANGAEA

SEISMIC TILTMETER SURVEY

EP167

**ENVIRONMENTAL MANAGEMENT PLAN
SUMMARY**

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1. INTRODUCTION

EP167 is located approximately 400 km southeast of Darwin in the Northern Territory (NT) in the Roper Basin. The tenements fall within the Victoria-Daly, Roper-Gulf and Barkly Shires plus the Katherine Municipality. All activities described in this EMP Summary are in the Roper-Gulf Shire.

Pangaea intends to undertake a seismic tiltmeter survey by acquiring surface seismic tiltmeter data around two Appraisal Well sites (Birdum Creek-1 and Wyworrie-1). The survey will record data around the existing Appraisal Well sites and will utilise tracks on pastoral land for which Pangaea currently have voluntary pastoral access agreements in place.

A location map and coordinates of the activity are provided in Figure 1.

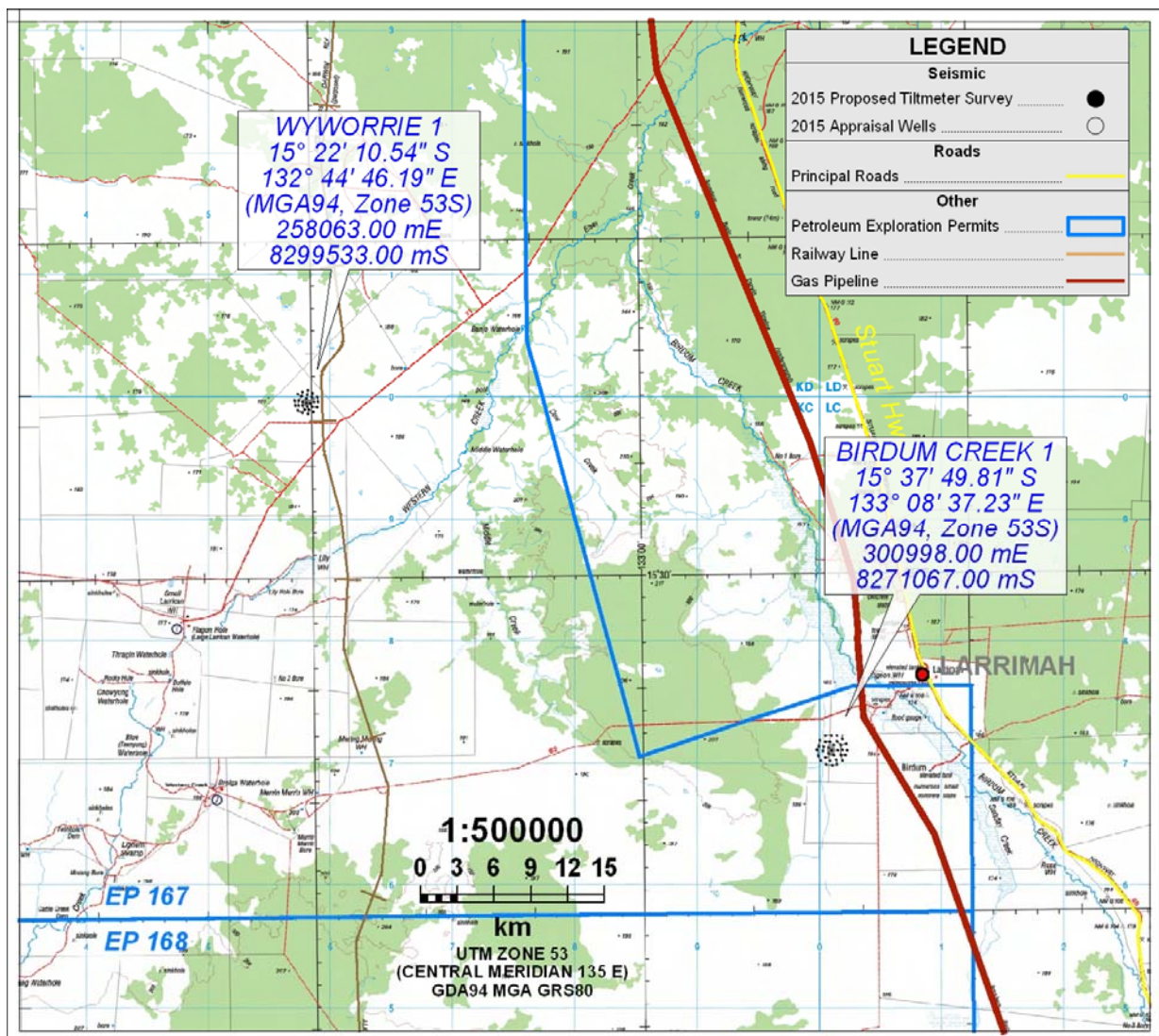


Figure 1: Location of the Seismic Tiltmeter Survey

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2. DESCRIPTION OF ACTIVITY

Tiltmeters are part of a suite of precision engineering tools and techniques used typically during the Appraisal stage. The overall objective of the seismic tiltmeter survey is to monitor subsurface geological formations across the two Appraisal Wells to increase the understanding of geologic stress fields within the area. This understanding, along with other scientific information gathered during the Appraisal stage, will assist with the design process for horizontal well trajectories.

Surface tiltmeter mapping involves measuring and processing data to infer hydraulic fracture geometry and related regional tectonic stresses exhibited within the targeted formations. Using highly sensitive calibrated measures, tiltmeters are able to measure very small movements and any small changes in the level are recorded using a standard datalogger. Tiltmeters measure their own tilt on two orthogonal axes. As the instrument tilts, a gas bubble contained within a conductive liquid fluid glass cavity moves to maintain its alignment with the local gravity vector. Precision electronics detect changes in resistivity between electrodes mounted on the sensor that are caused by repositioning of the gas bubble.

The survey has been designed in consultation with local pastoralists and traditional owners to avoid areas of environmental, cultural or archaeological importance.

3. DESCRIPTION OF THE ENVIRONMENT

The region's climate is *'semi-arid tropical, with rainfall concentrated in the wet season months between November and April. Though rainfall can be variable from year to year, there is a distinct gradient of decreasing mean annual falls from 850mm in the north to less than 500mm'* in southern areas of EP167 and EP168, with nearly all the rainfall occurring between November and April (see Williams *et al.* 1997¹, Hennessy *et al.* 2004²). The mean maximum temperature varies from 27°C in July to 40°C and beyond in November.

Condition is generally good across much of the bioregion. In EP-167, the seismic tiltmeter survey will intersect with the Forrest land system. The Forrest land system consists of gently sloping sandy surfaced plains with few indistinct drainage depressions on sandy red earth soils. Vegetation is dominated by eucalypt woodlands and perennial grasses, the systems are generally suitable for pasture improvement and have moderate to high grazing potential. The Forrest land system consists of vegetation that have a relatively low forage quality in the dry season but it can benefit from strategic burning to manage woody thickening (Northern Territory Government, no date³).

¹ Williams, R.J., Cook, G.D., Ludwig, J.L. and Tongway, D.L. (1997). Torch, trees, teeth and tussocks: disturbance in the tropical savannas of the Northern Territory (Australia). In: *Frontiers in Ecology. Building the Links*. Eds. N. Klomp and I. Lunt. Elsevier, Oxford: pp55-66.

² Hennessy, K., Page, C., McInnes, K., Walsh, K., Pittock, B., Bathols, J. and Suppiah, R. (2004). *Climate Change in the Northern Territory*. Consultancy report for the Northern Territory Department of Infrastructure, Planning and Environment. CSIRO, Melbourne.

³ Northern Territory Government (no date) *Land Condition Guide - Sturt Plateau District; Understanding the productivity of grazing lands*. Produced in association with the Northern Territory Cattlemen's Association as part of the Caring for Our Country project "Grazing Land Management – Demonstration, Continuation and Evaluation".

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4. DESCRIPTION OF THE ACTIVITY IN RELATION TO THE ENVIRONMENT

The Seismic Tiltmeter Survey has been designed with due consideration of the surface and subsurface environments, and to minimise impacts on the environment by utilising existing roads, tracks, fire-breaks and fence lines wherever possible. The operations will utilise one centrally located camp site.

Access track scouting, pegging and surveying involves the use of GPS by field staff to ensure the access track start and end points are clearly identified and marked. Pegging and surveying involves pre-site inspections, reconnaissance flagging, surveying a path and placing a peg in the ground at set intervals along the track to ensure the correct path is followed when preparing the sites and also clearly identify 'no-go' sensitive sites. These stages are minimal disturbance activities conducted from a 4WD vehicle or in some cases on foot.

Access track preparation may include 'stick raking' and vegetation management for technical, safety and visibility reasons. Stick raking displaces logs and large sticks from the chosen line that could create a hazard or barrier. Light grading may be required to smooth over very rough surfaces to make the line trafficable for the shallow drilling rig and support vehicles.

Bull-dozers may also be required as a last resort in areas where the terrain is especially rough and inaccessible by grader or front end loader. Tree clearing is minimised by meandering the tracks through heavily wooded areas and savannah woodlands around trees (>200mm Diameter at Breast Height), however some tree losses and trimming is to be expected. Before this occurs, all alternative options will be considered including practical re-routing to avoid clearing.

Where a track crosses a creek, watercourses or depression in the landscape, field staff will search for naturally cleared crossings (in the immediate area) for which to utilise before the final access tracks are chosen in the field. Earthworks in riparian areas will be minimised at all times and rehabilitation is to follow immediately post data capture, or as soon as practically possible.

Boreholes will be air drilled by local contractors to a depth of ~40 ft. (~12 m) at each tiltmeter station using the access tracks to move between the stations. The boreholes will have PVC casing to hold the tiltmeter. A tiltmeter is ~30" long and 2" in diameter and measure their own tilt on two orthogonal axes. As the instrument tilts, a gas bubble contained within a conductive-liquid-filled glass casing moves to maintain its alignment with the local gravity vector. Precision electronics detect changes in resistivity between electrodes mounted on the glass sensor that are caused by motion of the gas bubble. As the induced tilt is measured as a function of time, data will be captured throughout the course of the stimulation treatment. The tiltmeters will be retrieved and the data will then be processed to determine the geologic stresses in the area.

The tiltmeter is set for three (3) weeks to gather baseline data before the stimulation, and is removed post the stimulation treatment. The rehabilitation of the boreholes is completed with minimal disturbance to the surrounding environment.

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5. ENVIRONMENTAL RISKS OF PROPOSED ACTIVITY AND CONTROL MEASURES

Fauna and flora

The seismic tiltmeter survey has been designed to minimise clearing and associated impacts on important vegetation communities that may be proving important fauna habitat. The seismic tiltmeter survey would comprise a minor and temporary barrier to movement of fauna, however the small scale of vegetation modification is unlikely to isolate any wildlife corridors or otherwise affect the migration or dispersal ability of any fauna. Weed and pest inspections on all vehicles & personnel clothing will be undertaken prior to arrival at site and via the use of signage and appropriate fencing.

Noise and surface

Speed limits will be enforced on access tracks to limit and minimise dust and noise generation. Vehicular movements to and from the work sites will be minimised by travel during daylight hours and be compliant with land access agreements. Soil erosion will be minimised by the use of existing tracks, deviating around creeks, river banks and naturally formed depressions and not accessing roads in wet conditions.

Waste management

Waste will be stored in suitable receptacles and disposed of accordingly at municipal managed locations. Waste material shall be transported, stored and handled in accordance with the requirements of the relevant legislation and guidelines.

6. CONSULTATION

During the past several months Pangaea has consulted with stakeholders, which has included:

- A detailed cultural heritage assessment and sacred site clearance process with the Northern Land Council and Traditional Owners;
- The negotiation and signing of voluntary access agreements with directly-affected Pastoralists;
- Direct engagement with communities and representative groups at exhibition booths during district and agricultural shows e.g. Katherine and Tennant Creek District Shows (2014, 2015);
- Notification to local government councils, police authorities and local businesses of exploration activities; and
- Compliance with legislation and guidelines from the NT Department of Mines and Energy and other regulatory agencies e.g. Department of Transport and Department of Infrastructure.

Pangaea's engagement process is aimed to identify and address issues of concern, reach agreement and in general engage in goodwill communication.

Pangaea will continue this process with stakeholders throughout the life of the project.

7. PANGAEA LIAISON PERSONNEL

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