Stenger, R., Wilson, S., Clague, J., Rivas, A., Barkle, G., Durney, P., Moorhead, B. 2020. SkyTEM surveys for catchment-scale hydrogeophysical exploration. In: *Nutrient Management in Farmed Landscapes*. (Eds. C.L. Christensen, D.J. Horne and R. Singh) http://flrc.massey.ac.nz/publications.html. Occasional Report No. 33. Farmed Landscapes Research Centre, Massey University, Palmerston North, New Zealand. 4 pages.

SKYTEM SURVEYS FOR CATCHMENT-SCALE HYDROGEOPHYSICAL EXPLORATION

Roland Stenger[1], Scott Wilson[2], Juliet Clague[1], Aldrin Rivas[1], Greg Barkle[3], Patrick Durney[2], Brian Moorhead[1]

[1]*Lincoln Agritech, Private Bag 3062, Hamilton 3240, Aotearoa New Zealand*
[2]*Lincoln Agritech, PO Box 69133, Lincoln 7640, Aotearoa New Zealand*
[3]*Land and Water Research, PO Box 27 046, Garnett Ave, Hamilton 3200, New Zealand*
Email:Aldrin.Rivas@lincolnagritech.co.nz

Introduction:

The need to understand nutrient transfers into lower-order waterways, i.e. streams operating at the farm to sub-catchment scales, is increasingly being recognised. The MBIE-funded Critical Pathways Programme (CPP) aims to unravel and model the relatively shallow and short pathways responsible for these nutrient transfers. While geospatial datasets are widely available for the soil (S-map, FSL) and for the geology (QMAP), there is a scarcity of data for the critical zone in-between, which strongly affects the contaminant transfers at relatively shallow depths (top 20 to 50 m).

Information on this critical subsurface zone has to date largely been derived from point-scale logging during the costly installation of groundwater bores. Airborne transient electromagnetic surveys (e.g. SkyTEM) have the potential to provide related information in much greater spatial resolution in a time-efficient manner. Accordingly, in 2019, we carried out the first SkyTEM surveys in NZ in two study catchments: the Piako River headwater catchment (≈100 km^2) on the Hauraki Plains and the Waiotapu Stream catchment (≈300 km^2) on the Central Plateau (Fig. 1).

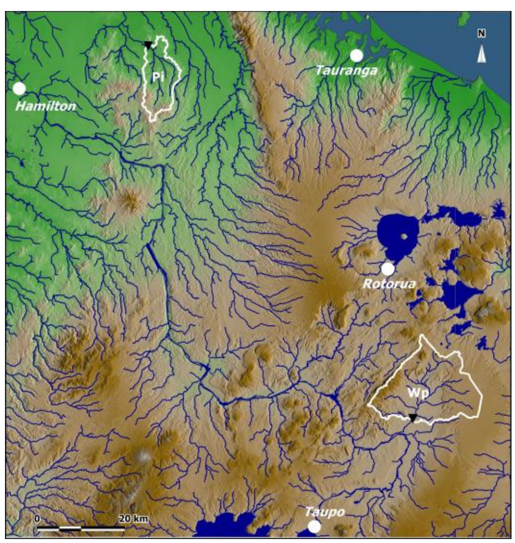

Fig. 1: Location of study catchments where SkyTEM aerial surveys were carried out in February 2019. Pi = Piako River headwater catchment and Wp = Waiotapu Stream catchment.

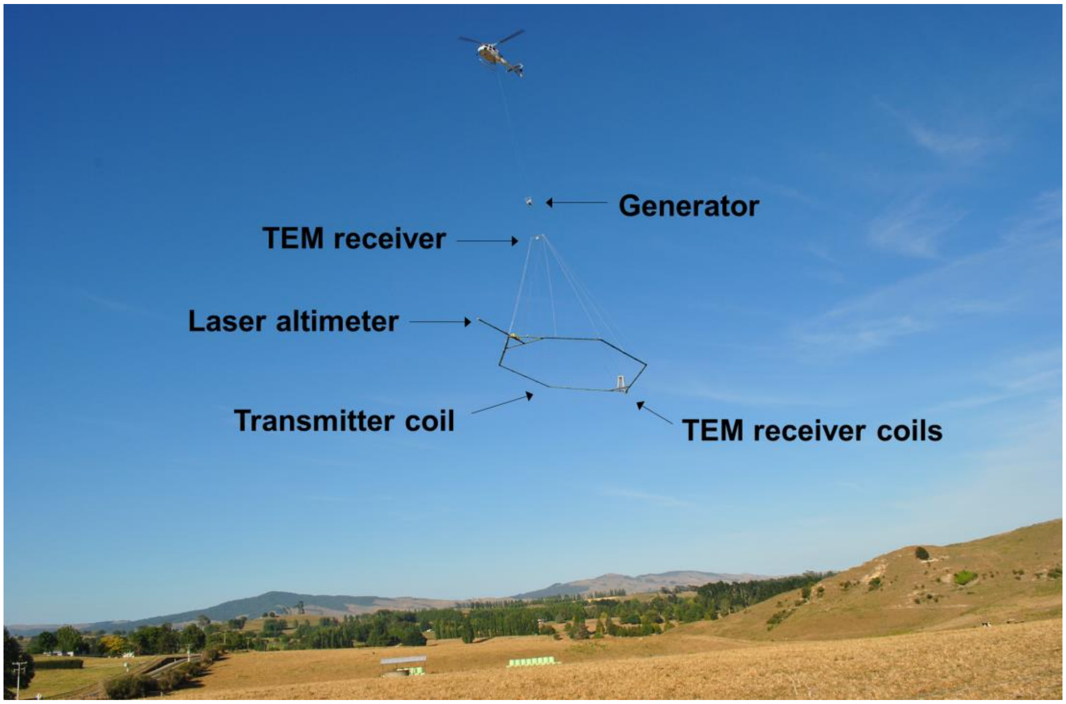

Fig. 2: Helicopter and instrumentation used in the SkyTEM survey, February 2019.

Methods:

The instrumented frame (Fig. 2) was carried below the helicopter at approx. 35 m above the ground surface, with the helicopter flying in parallel lines 200 m apart, at a height of 90 m and speed of 80-100 km hr^{-1}. The surveys covering the catchments were completed in 2 days in the Piako and 5 days in the Waiotapu catchment, without any major inconvenience to the local communities (e.g. stock disturbance).

The collected data allows the subsurface structure to be described in terms of electrical resistivity ($\Omega \cdot m$) or its inverse, electrical conductivity (mS m^{-1}). The vast amount of electrical resistivity raw data generated required comprehensive automated and manual processing before reliable pseudo 3D resistivity models could be created, using software developed by Aarhus University, GeoScene3D (Fig. 3).

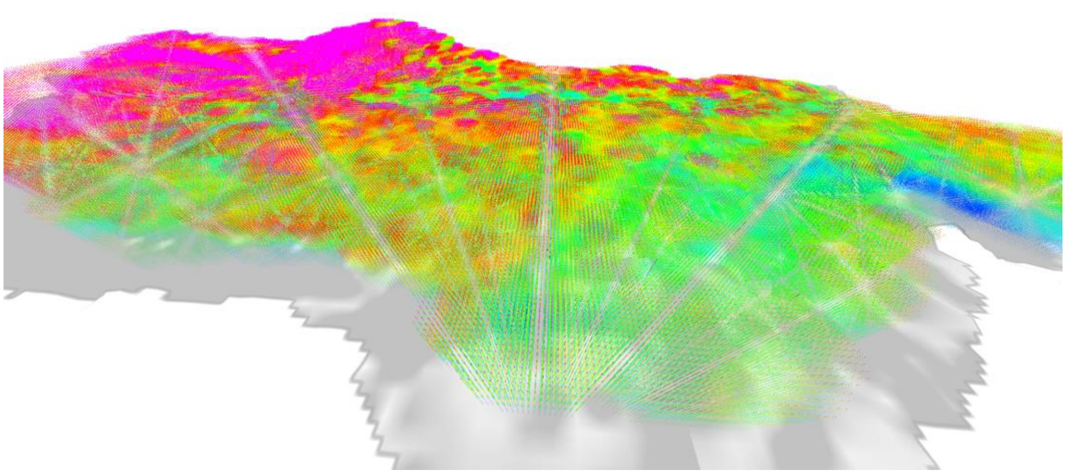

Fig. 3: Continuous resistivity image generated in GeoScene3D software from SkyTEM data for the Waiotapu catchment.

Results:

The reliable depth of investigation ranged from ≈50 m where very low resistivity material occurred near the surface to ≈300 m, with many areas yielding reliable data for ≥200 m.

Data gaps caused by electromagnetic couplings reflect the density of roads, railway and power lines, and can be seen as the grey areas in Fig. 3. These gaps present a challenge when interpreting the data, particularly as both catchments have a high degree of lateral and vertical heterogeneity (Fig. 4).

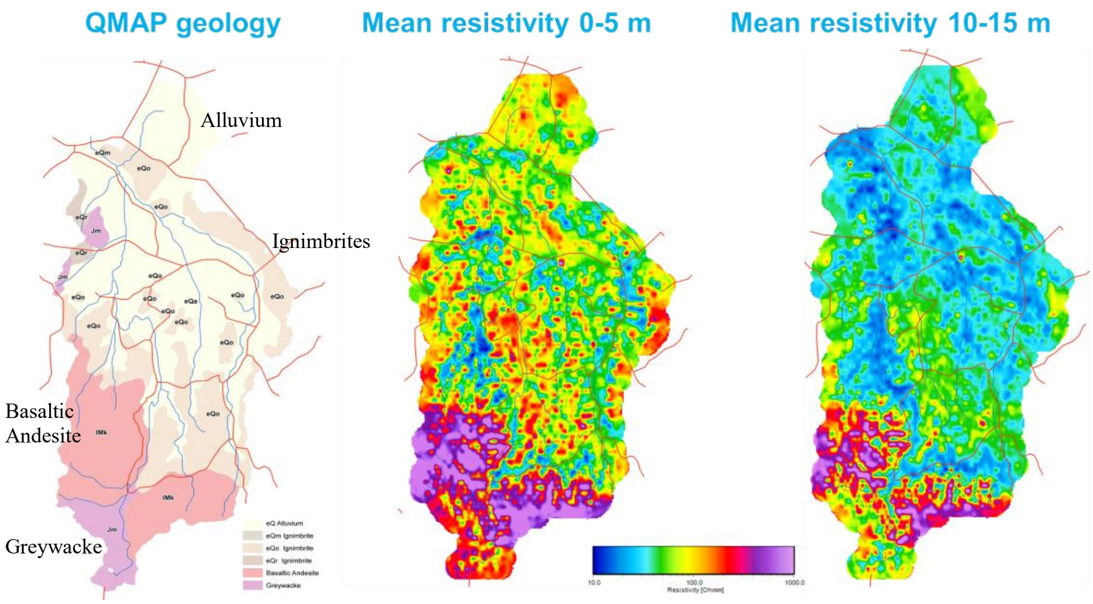

Fig. 4: Comparison between QMAP surface geology patterns and SkyTEM resistivity patterns at 0-5 m and 10-15 m depth in the Piako River headwater catchment.

As the relationship between electrical resistivity and hydraulic conductivity is non-unique (also affected by porosity, salinity, etc.) comprehensive ground-truthing is required to enable meaningful interpretation of the resistivity models. However, in many locations of the catchments, high quality geological information is lacking (Fig. 5), therefore future work will include detailed logging of new boreholes in strategic locations. This information will be gathered in 2020, along with smaller scale, but higher resolution ground-based tTEM surveys in collaboration with Aarhus University.

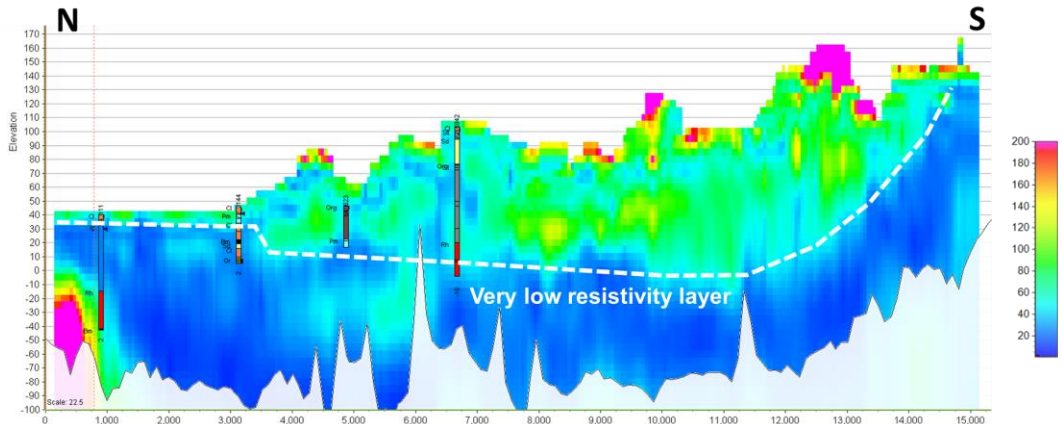

Fig. 5: A north to south cross section of SkyTEM resistivity data in the Piako River headwater catchment, with bore log information, where available.

Conclusion:

The aerial surveys captured a large amount of catchment-scale data in a relatively high spatial resolution in a time-efficient manner. Sophisticated raw data processing allowed reliable pseudo 3D resistivity models to be created. However, as resistivity is affected by numerous factors, hydraulic conductivity cannot directly be derived from it. Comprehensive ground-truthing, utilising a range of independent data types and data analytics techniques, is required to ensure the 3D resistivity models are interpreted in a manner informative for hydrological modelling.

Acknowledgements**:** This research benefits from collaboration with Aarhus University, the Geological Survey of Denmark and Greenland (GEUS), and the Technische Universität Dresden. Funding is primarily provided by the NZ Ministry of Business, Innovation and Employment with additional support from Waikato Regional Council and DairyNZ.