
MINE SHIFT:
Monitoring subsidence
risks of longwall coal mining
CATALYST

# By the very nature of its method, longwall coal mining can create a risk of major subsidence.

Open voids – once filled by massive coal deposits – are deliberately and safely collapsed as the mining moves through the landscape hundreds of meters underground.

On the surface, the result can be rapid vertical and horizontal displacement – the extent of which is dependent on the structural integrity of the mine's roof – as the topography settles into its new constitution.

Not only does this displacement create major risk to miners' safety, requiring vigilant and robust mitigation protocols, but it can also impact the neighbouring environment, communities, and infrastructure – often located near these coal deposits.

The Tahmoor and Appin mines in New South Wales, Australia, are two such examples of how the overlap of approved longwall mining with local communities and infrastructure poses a diverse range of safety, operational, and strategic challenges.

Together Tahmoor and Appin consist of more than 50 longwalls located between Bargo and Douglas Park, with the mining activity targeted on the Bulli Seam located approximately 300 to 500m below the surface. The width of the seam typically varies between 1.8 and 3.3m along the slice[1].

The Tahmoor mine alone is projected to yield four million tonnes (Mt) of coal annually, with an estimated total extraction of up to 33Mt by the end of operations in 2032. The mine's operational lifespan is anticipated to surpass 50 years.

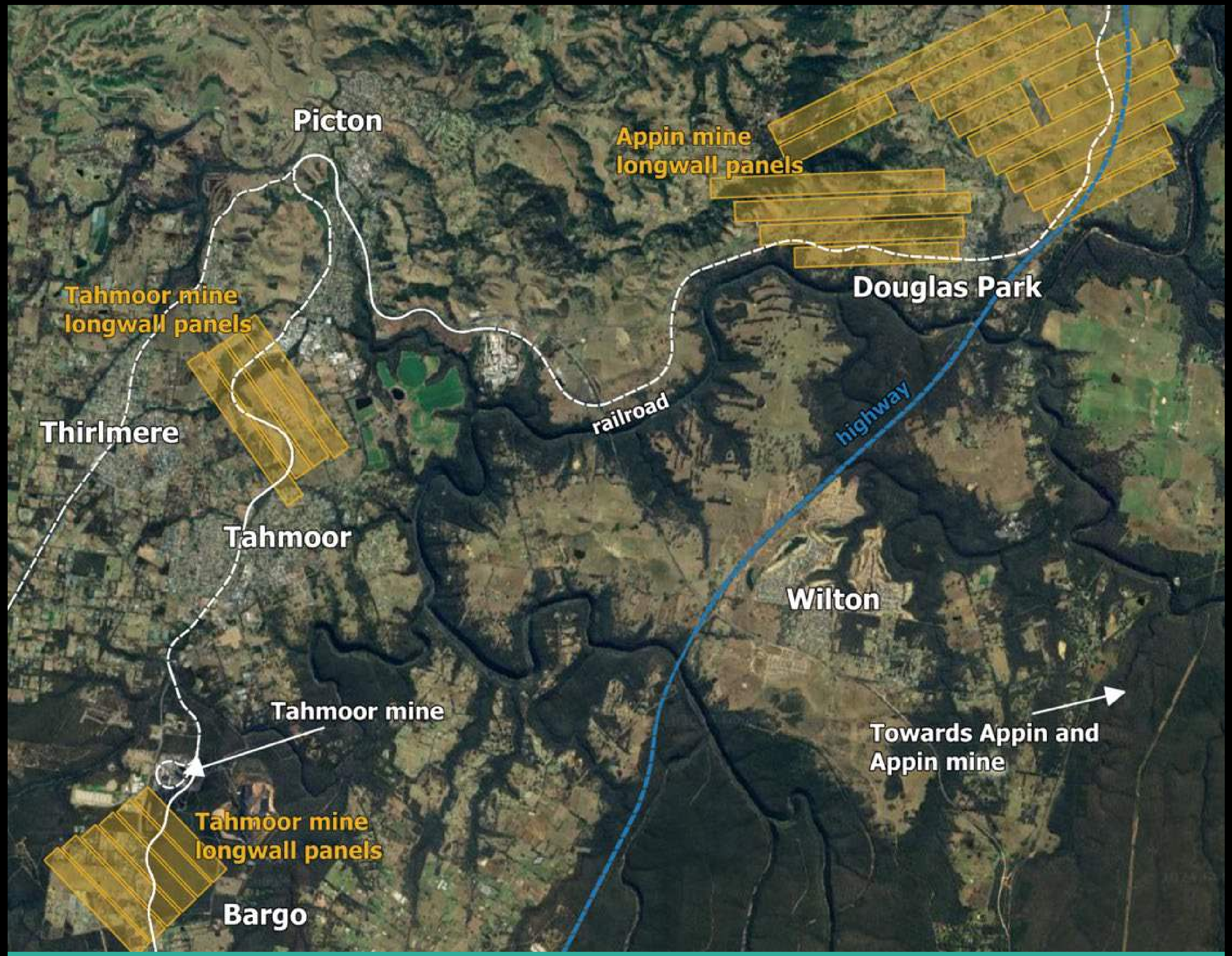
While longwall mining is efficient, with typical resource recovery of around 80%, the associated high-level subsidence risks require extensive environmental and planning studies, impact assessments, and approvals before operations can begin.

And once activity has begun, the impact on the surrounding land needs to be closely monitored.

Like many mining projects, tracking the impact of longwall sites largely remains a manual process, but there are huge opportunities to improve this using Earth Observation (EO) analytics.

In this edition of Mine Shift, we've analyzed the subsidence extents at both Tahmoor and Appin, to review the impact of recent activity and unearth notable trends and hotspots.

**Here's what we found >>**




### What is longwall mining?

Formerly known as the Shropshire method – named after the place of its origination in the late 17th century – longwall mining involves cutting along the face of coal panels deep underground.

In place of where the coal once was, powered roof supports are positioned within the cavity – called a goaf – to reinforce the roof and protect miner safety while a mechanized shearer cuts along the coal face at speeds of 10-30m/min.

As activity progresses and the goaf increases, the supports are moved forward and the roof behind is allowed to collapse to fill the space.

1 https://www.mining-technology.com/projects/tahmoor-south-project-nsw/

# A close-knit neighborhood.

First and clearly noticeable at both Tahmoor and Appin is the exceptionally close proximity of the longwalls to residential and commercial property, as well as crucial rail and road transport links.

At certain points, the extraction activity occurs directly below housing, business estates, railways, and parts of the road network.

We used openly available mine maps in a GIS georeferencing tool to produce a geospatial digital representation of the mining locations. For mine operators, there are several practical applications of having clear visibility of their underground longwall locations from a satellite perspective.

modelling, combining locations with known geographical features to enhance foresight and support risk mitigation activity.

It also provides anchor points from which to combine feature extraction and InSAR analysis of targeted areas – such as railways – to conduct more thorough subsidence monitoring in key locations.

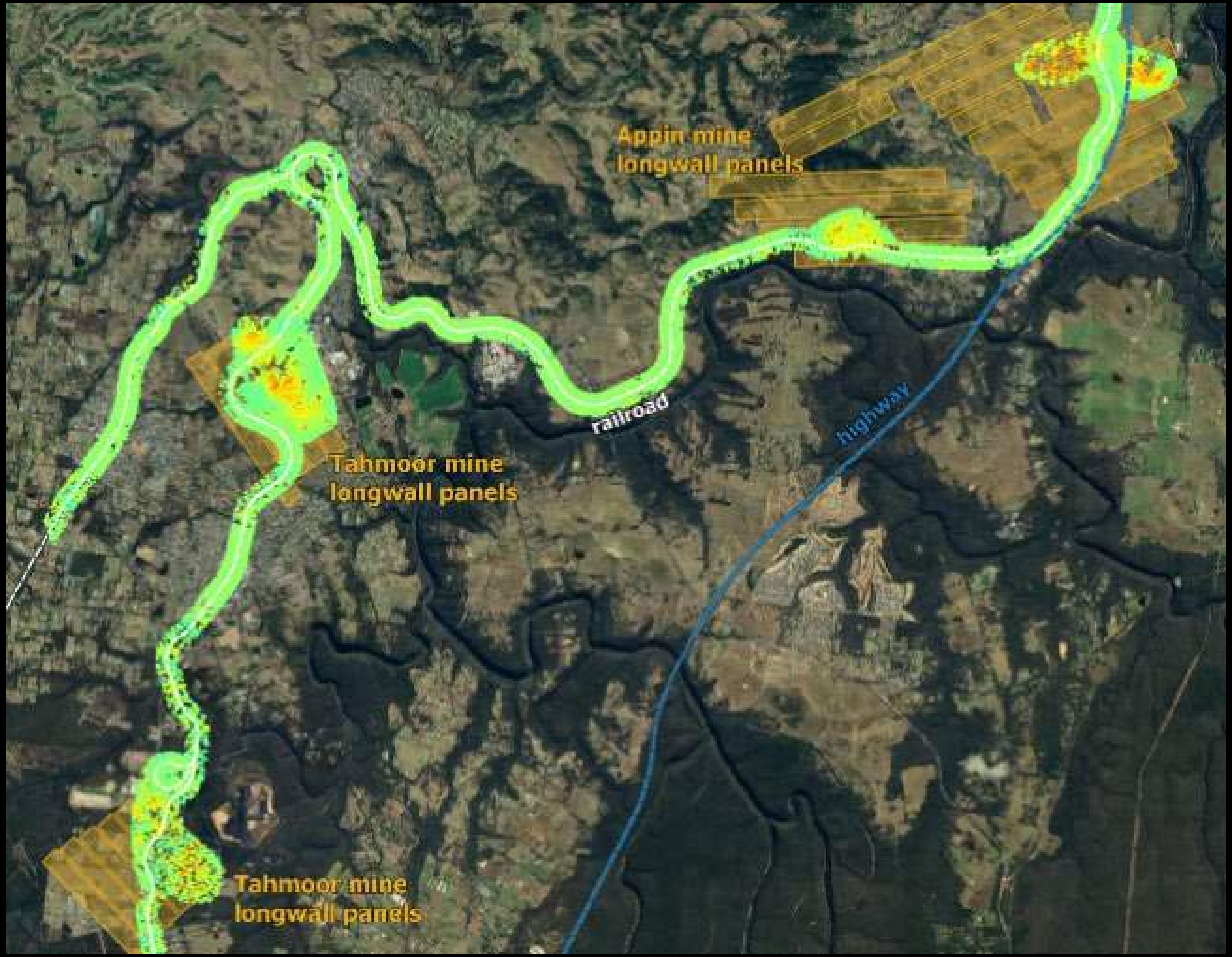
# A close-knit neighborhood.

For our analysis, we focused on the rail line from Bargo (in the south) up to and past Douglas Park (in the north).

There are clear displacement points along the rail line at each longwall location, with both moderate and high levels of localized subsidence, likely caused by the underground activity.

At the Appin longwalls in the north, displacement points were also identified intersecting a public highway, with yet more moderate and high-level subsidence evident.

At all locations, these displacement measurements would meet CATALYST's threshold for further monitoring and inspection.




**What is InSAR?**

InSAR stands for Interferometric Synthetic Aperture Radar. It's a radar technique used in geodesy and remote sensing to measure the Earth's surface deformation with very high precision.

It works by comparing the phase of radar waves from satellite images acquired at different times over the same area. Changes in the phase indicate movement of the Earth's surface, which can be caused by various factors such as earthquakes, landslides, mining or even subtle shifts in the ground due to groundwater extraction and infrastructure development.

This technology is incredibly useful for monitoring and understanding natural and human-induced changes in the Earth's surface over time.

# With EO, it's not always about the bigger picture.

A major benefit of EO analytics for corridor monitoring is its capacity to analyse across vast expanses of the Earth's surface, giving teams macro views of their sites simply not possible with in situ instrumentation.

As soon as our team identified hotspots of subsidence at this bigger picture level, the next step was to examine the detail.

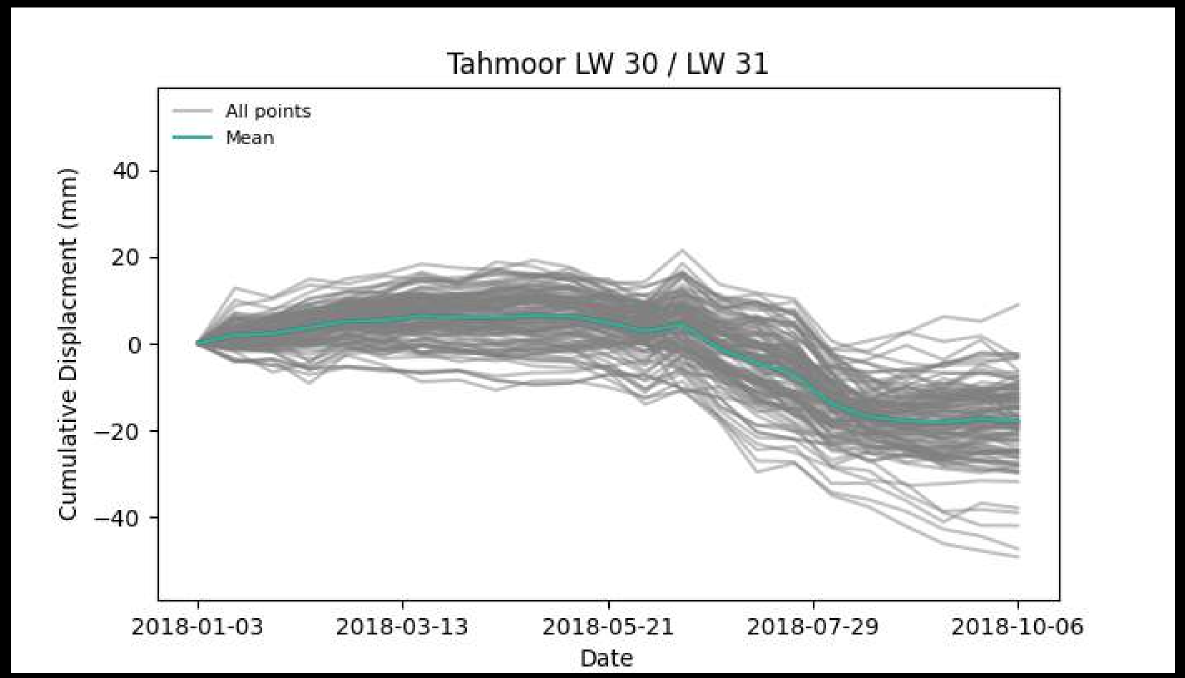
The following observations are the results of InSAR analyses we ran for two time periods: 3 January to 6 October 2018 and 7 April 2023 to 1 April 2024.

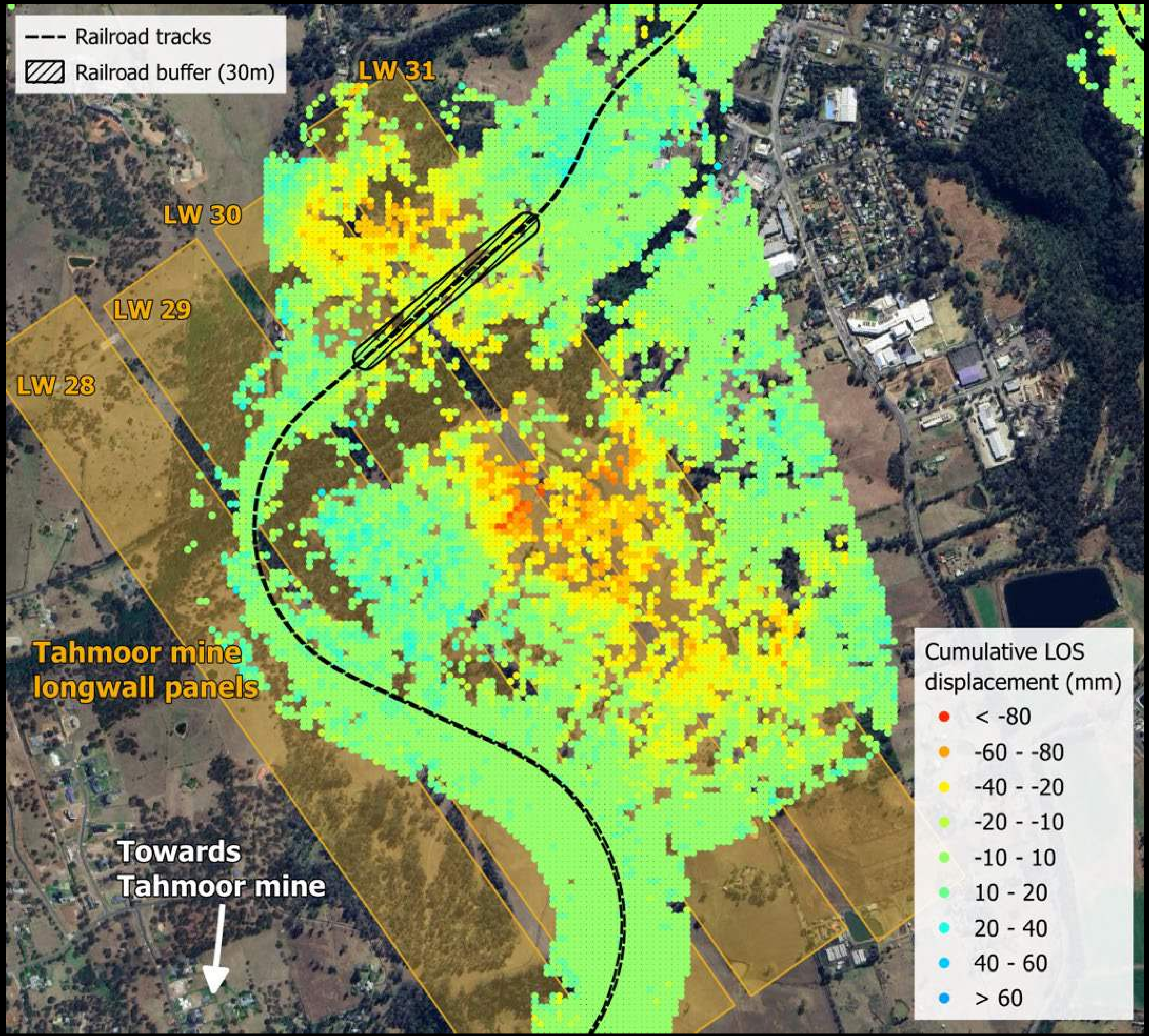
For the two time periods, we focused on three areas along the railroad and a nearby highway.

The first were Tahmoor longwall panels 30 and 31, situated between the towns of Tahmoor and Picton in the Tahmoor North lease area.

A segment of the railroad (highlighted by the hashed area) began subsiding in mid to late May 2018, with an average cumulative LOS displacement of -18 mm.

As evident in the accompanying time series chart, some areas of the railroad segment experienced as much as -49 mm of movement in a rapid period.

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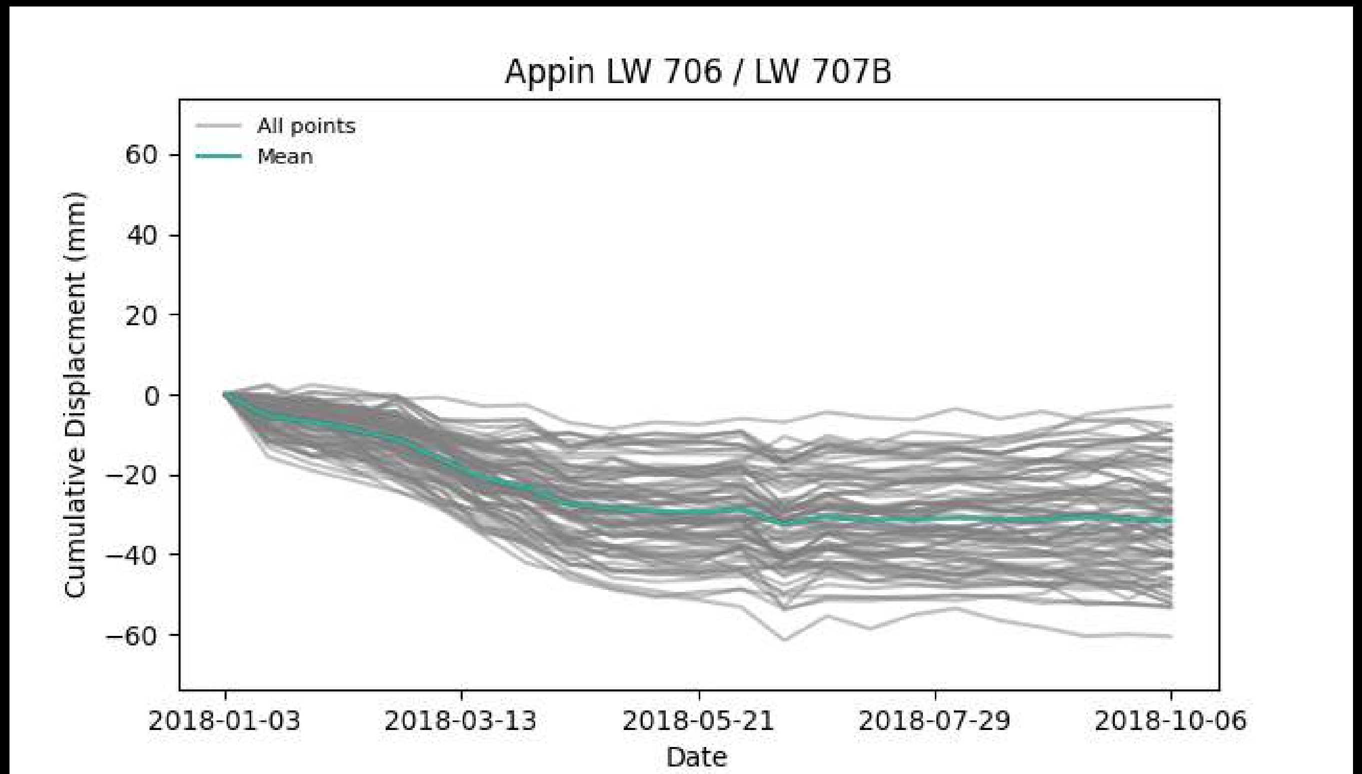
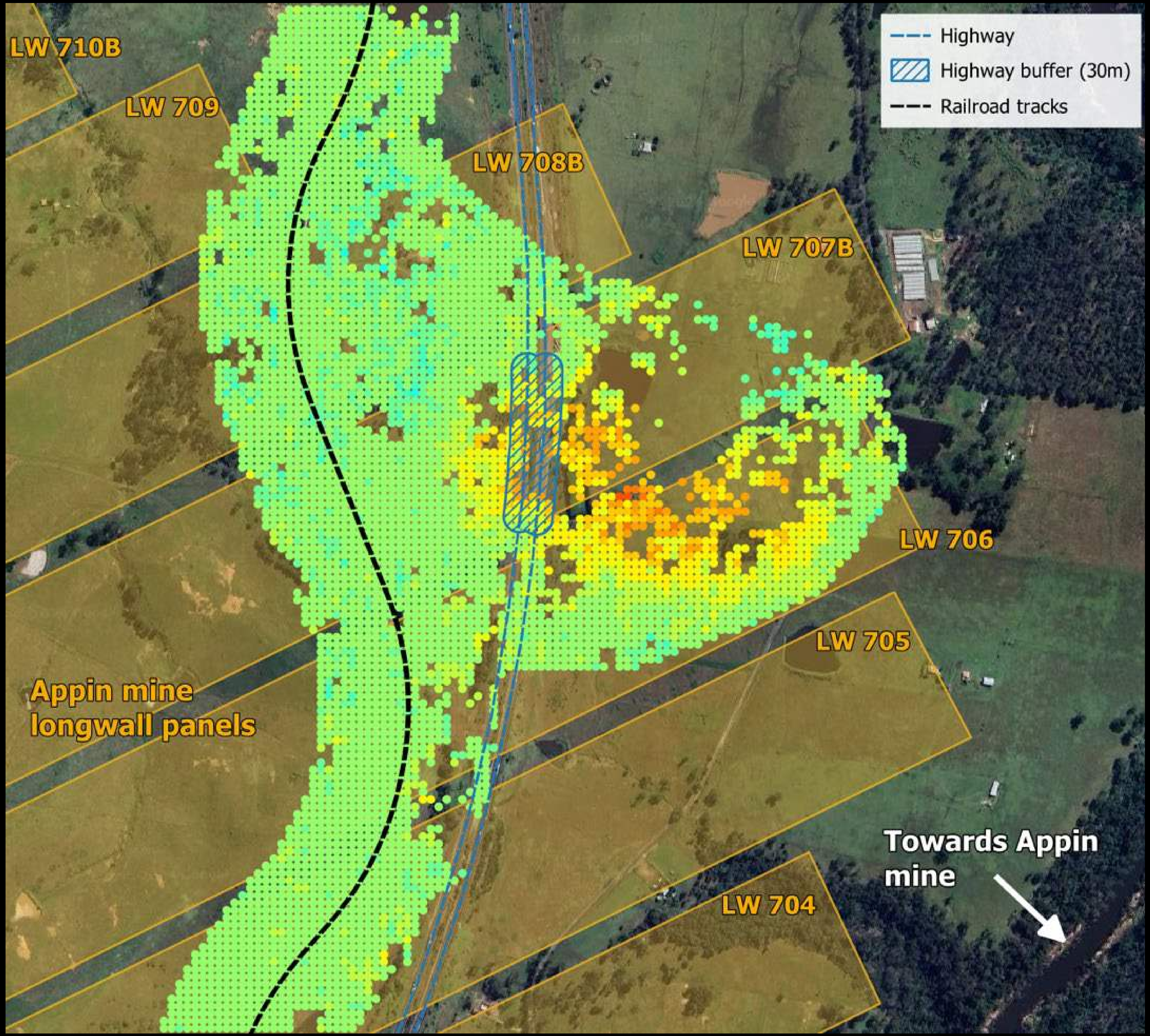
# With EO, it's not always about the bigger picture.

That same year, Appin mine longwall activity caused subsidence of the highway near Douglas Park.

A section of highway over longwalls 706 and 707B experienced an average cumulative subsidence of -32 mm and as much as -61 mm.

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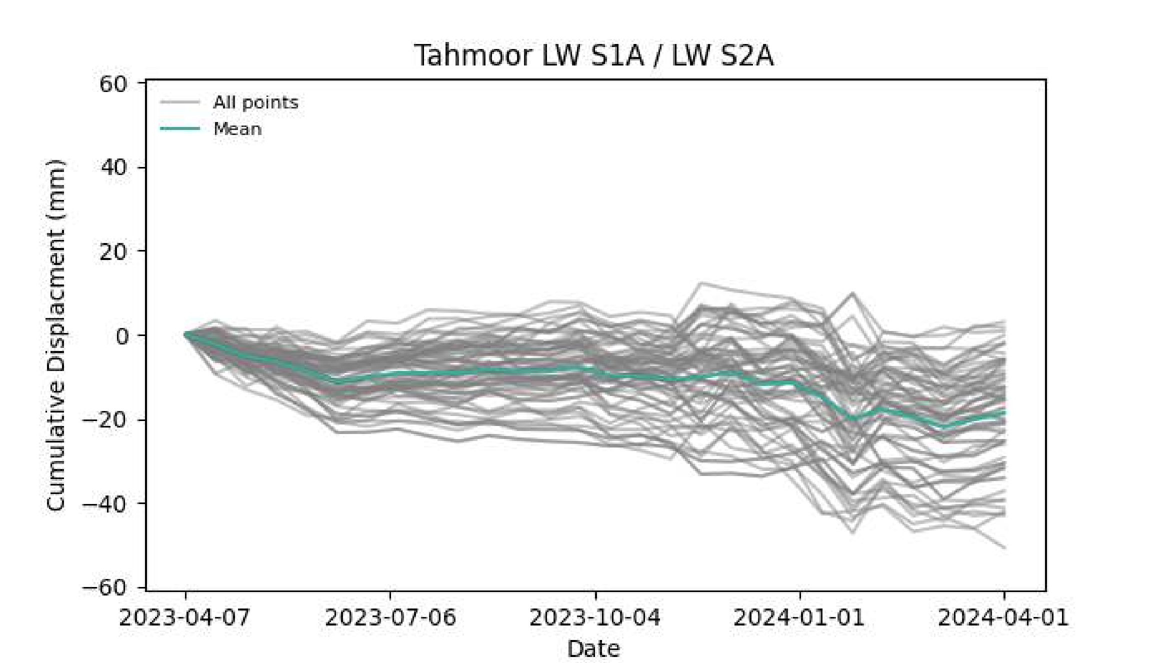
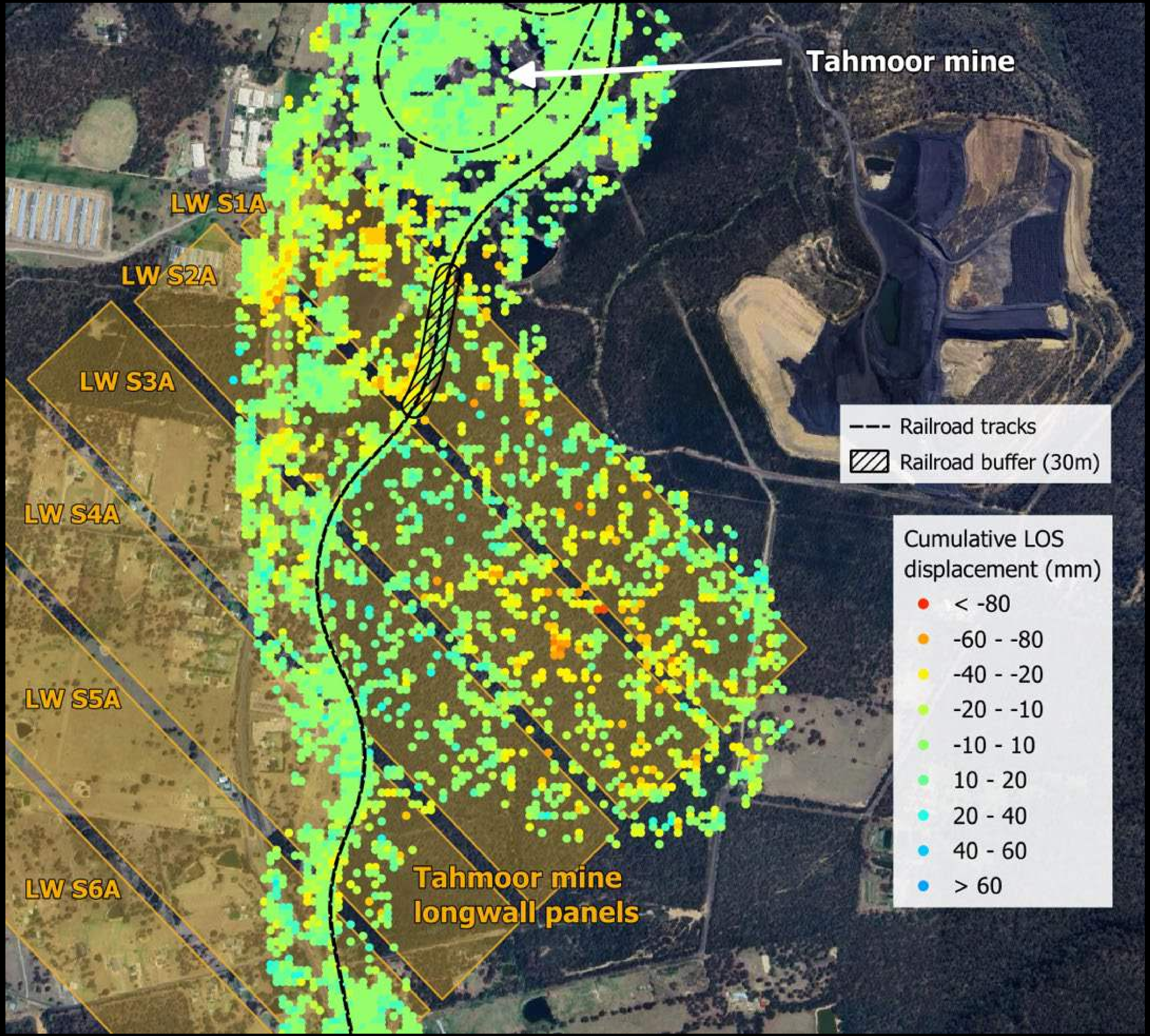
# With EO, it's not always about the bigger picture.

More recently, and further south near Bargo at Tahmoor longwalls S1A and S2A, two periods of subsidence were detected at the railroad: one prior to April 2023 and again in December 2023.

The average cumulative LOS displacement recorded over this segment was -19 mm, with some areas experiencing as much as -51 mm of subsidence.




### Costly impact of longwall mining subsidence

While surface effects are anticipated, subsidence isn't without its costs.

Longwall coal mining operations typically forecast significant expenditures in the tens of millions for subsidence damage to properties and infrastructure.

During longwall mining in the Tahmoor/ Picton area (longwalls 22 to 29), the repair costs for homes affected by coal mine-induced subsidence averaged $75,000.

Between 2004 and 2016, Tahmoor Colliery alone disbursed over $50 million for residential property damages.

This figure is closer to $65 million when also considering expenditures for damages to linear infrastructure, like railways, local roads, and sewer networks[2].

[2] https://data.nsw.gov.au/

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# Longwall mining operations can benefit significantly from InSAR technology.

As a mining modality where subsidence impact on property and transport corridors is not an 'if', but a 'when' scenario, the capacity for longwall mining operators to access both historical and current InSAR analytics has several transformative benefits.



# Longwall mining operations can benefit significantly from InSAR technology.

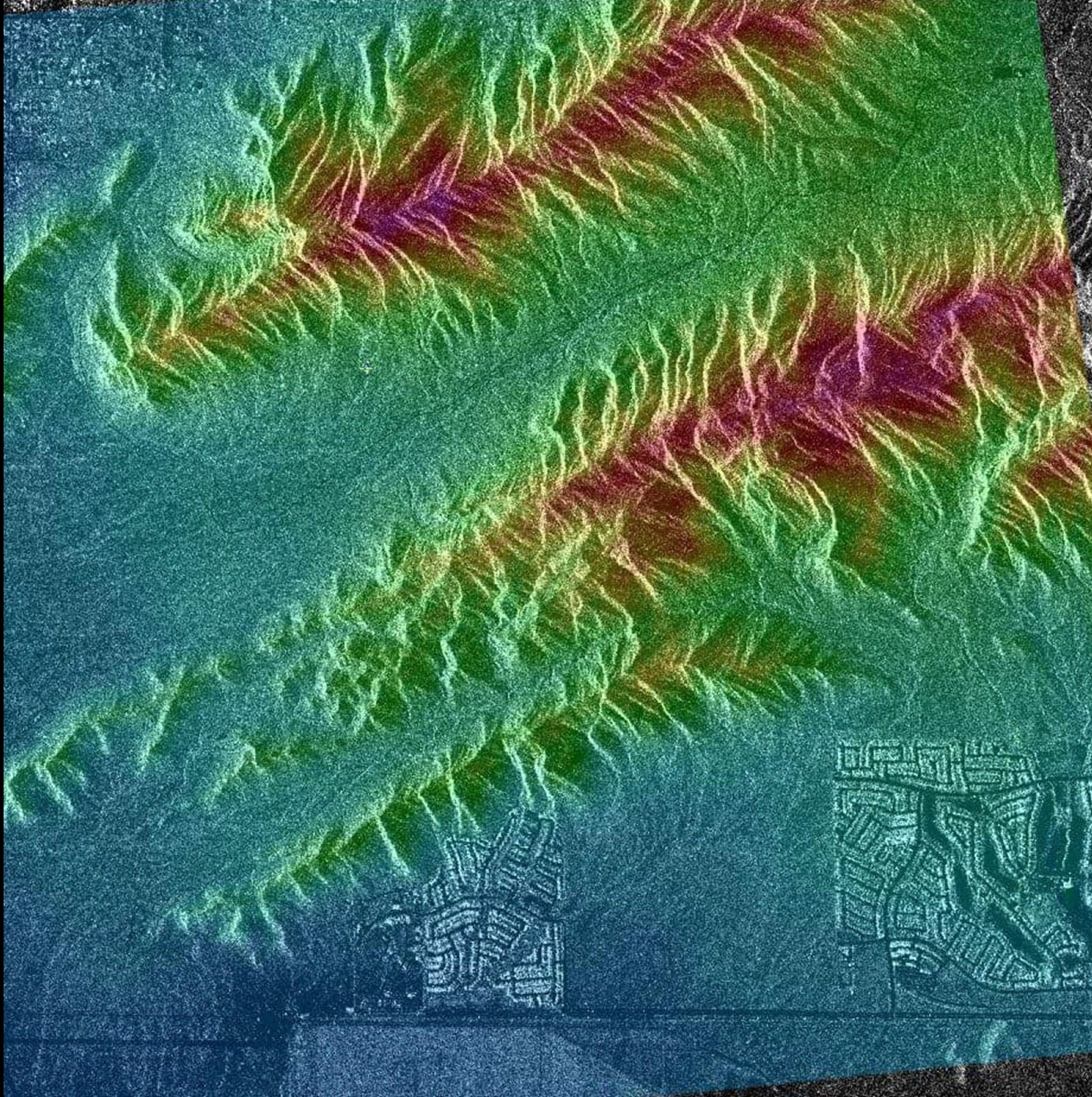
**Looking back to look forward with more clarity.**
With historical analyses, decision makers within these teams can verify the precision of predictive subsidence models by leveraging InSAR measurements made during past mining activities.

By validating the accuracy of these models, mining operators gain invaluable insights that drive more informed decision-making processes.

Future subsidence models can subsequently be fine-tuned with this information, potentially providing significant enhancements to predictive accuracy. The result? A tangible improvement in forecasting the costs associated with subsidence-related repairs to houses and critical infrastructure.

By focusing pre-mining strengthening efforts on high-subsidence risk areas, operators can ultimately mitigate risks, potentially reducing both the frequency and financial impact of future subsidence damage claims.





# Longwall mining operations can benefit significantly from InSAR technology.

**From millimeter measurements to actionable intelligence.**
From thousands of displacement measurements, we distill every millimeter into easy to use, user friendly data visualizations for simple, faster insights.

Whatever your asset type, location, or size, CATALYST solutions can be configured to meet the exact requirements of your monitoring needs, with custom alerts set up to prioritize emerging trends your team need to know about, when they need to know about them.

Considering the potential impact of sudden, rapid changes in negative displacement directly on or near infrastructure, being equipped with fast, actionable intelligence enables more informed decision making when it matters most.

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# Longwall mining operations can benefit significantly from InSAR technology.

**Expand your daily coverage.**
In situ, manual inspections are only capable of covering finite distances at a time.

With satellite technology, however, entire asset locations across diverse topographies can be placed under constant, continual surveillance at a greater cost efficiency.

In the examples shown in this edition of Mine Shift, the total surveillance size was more than 252km$^2$.

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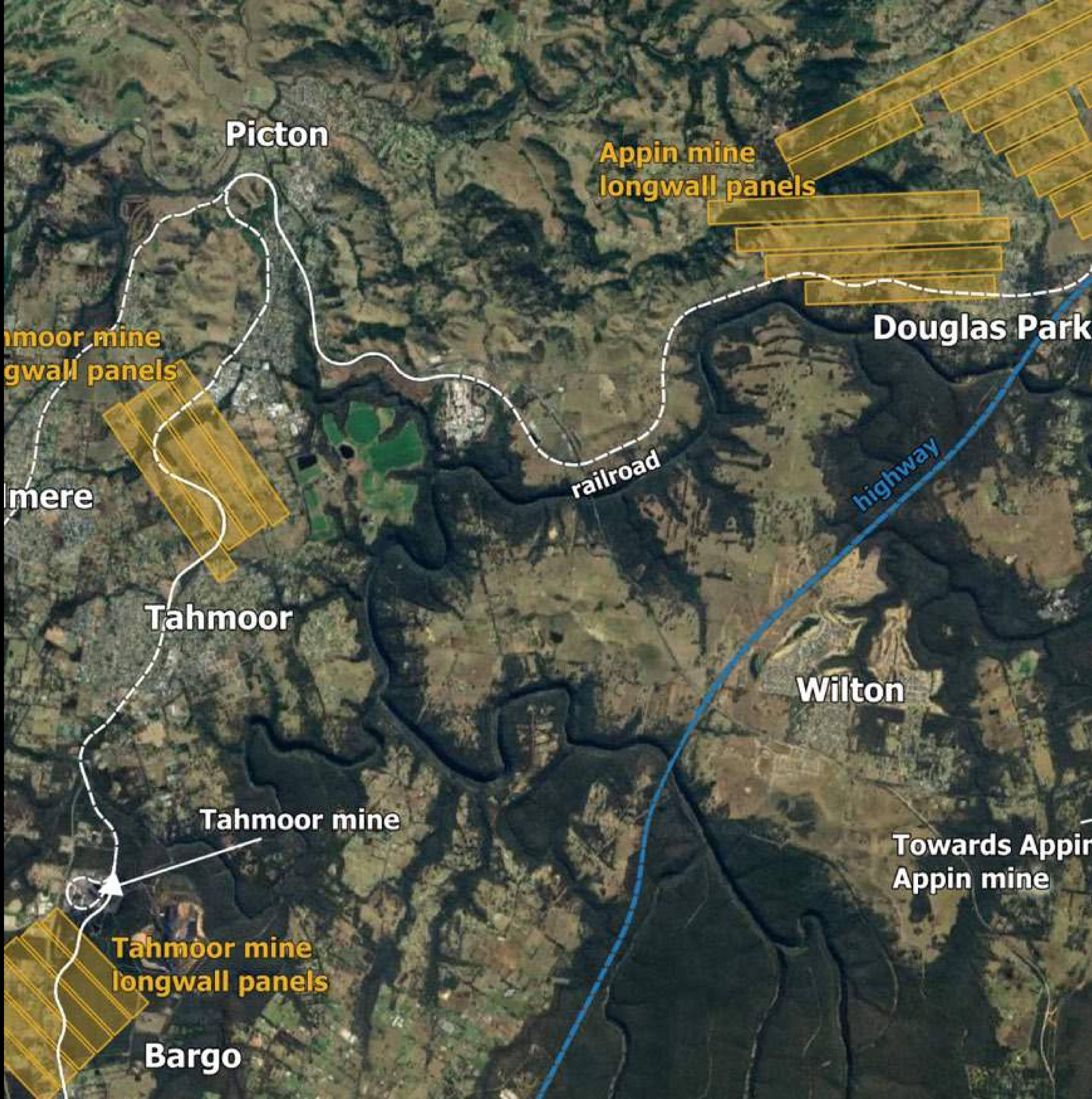
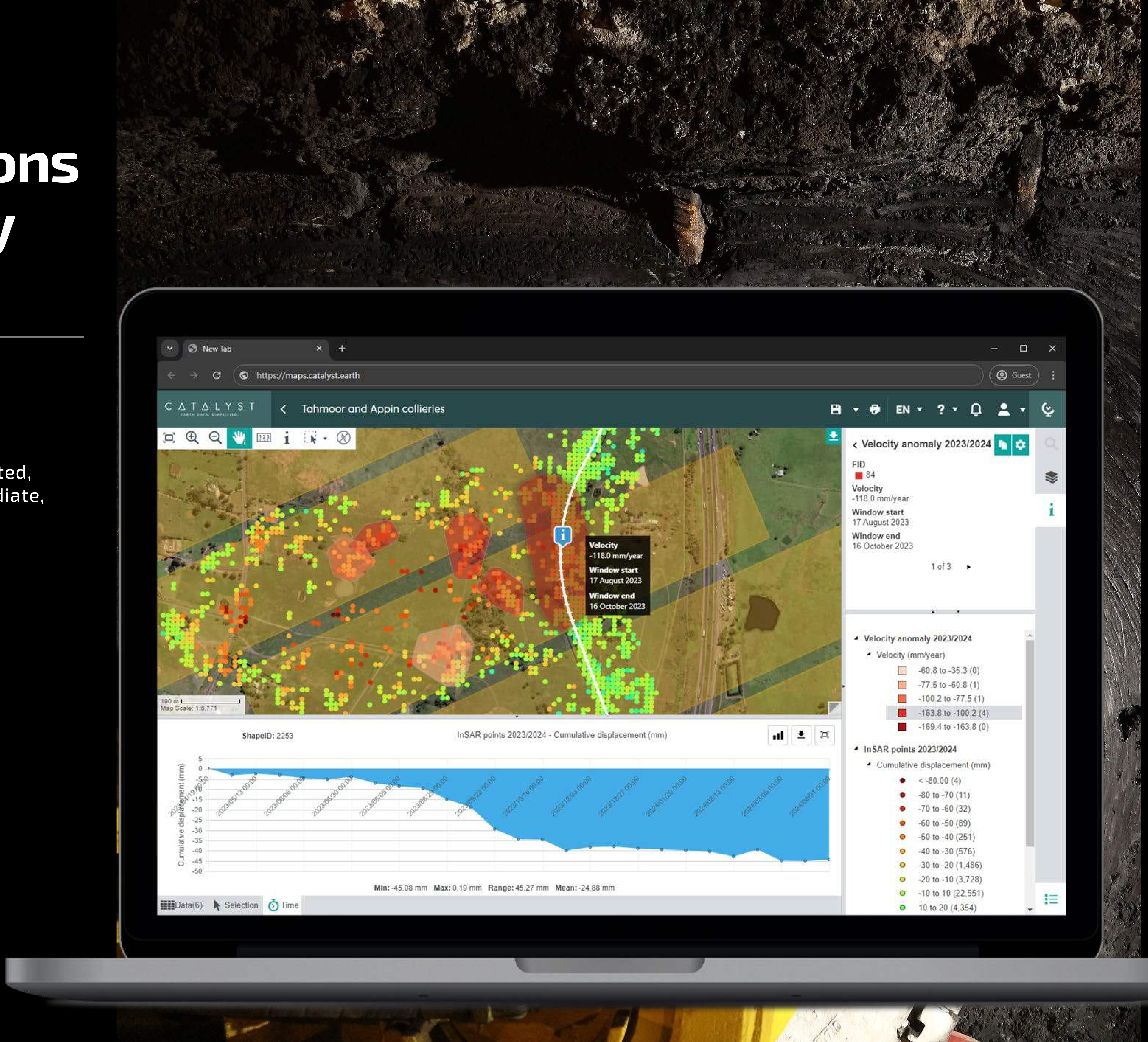


# Longwall mining operations can benefit significantly from InSAR technology.

**Always on, always alert.**
As we saw across our analysis periods at both Tahmoor and Appin, negative displacement changes can happen rapidly.

With CATALYST InSAR, those subtle and sudden changes can be detected, analyzed, and reported in near-real time, providing teams with immediate, actionable insight to not only respond faster, but do so with targeted precision.

This invaluable information enables proactive asset management strategies, ensuring the protection of critical infrastructure and minimizing operational disruptions.

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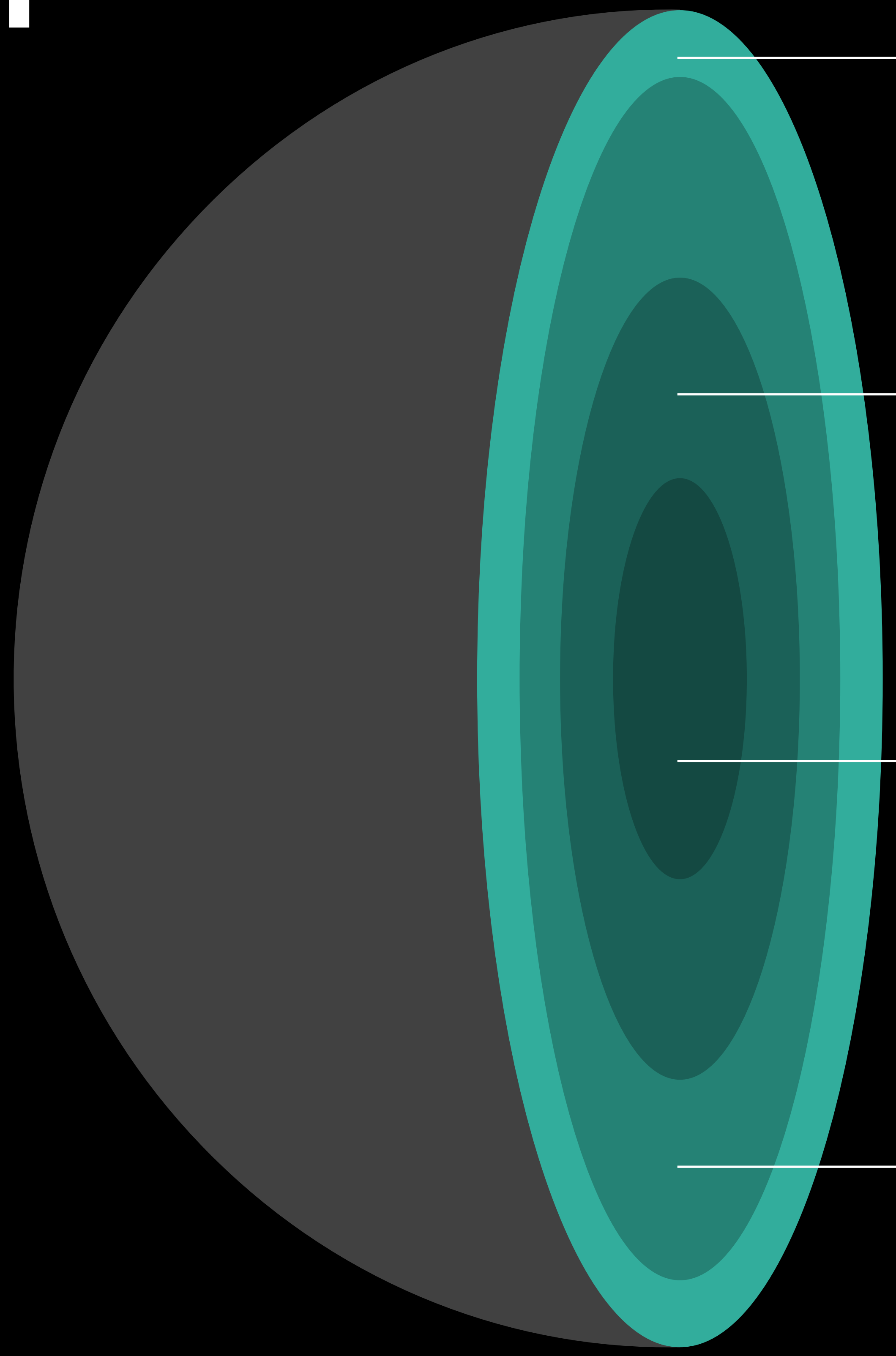
# Discover what CATALYST can do for you



Earth observation and ground displacement technology is no longer a tool for the specialists.

Thanks to our cloud-based innovations, CATALYST solutions are available to all businesses, teams, and decision makers.

Integrated seamlessly into your workflows without the need for technology upgrades, they can have an immediate transformative impact on your strategies and outcomes.

**Discover what they can do for you.**
**Get in touch with our team today.**

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