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Surat Gas Project

Duleen Kupunn area
Area wide planning update

14 May 2021

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Safe Work. Strong Business.

Agenda



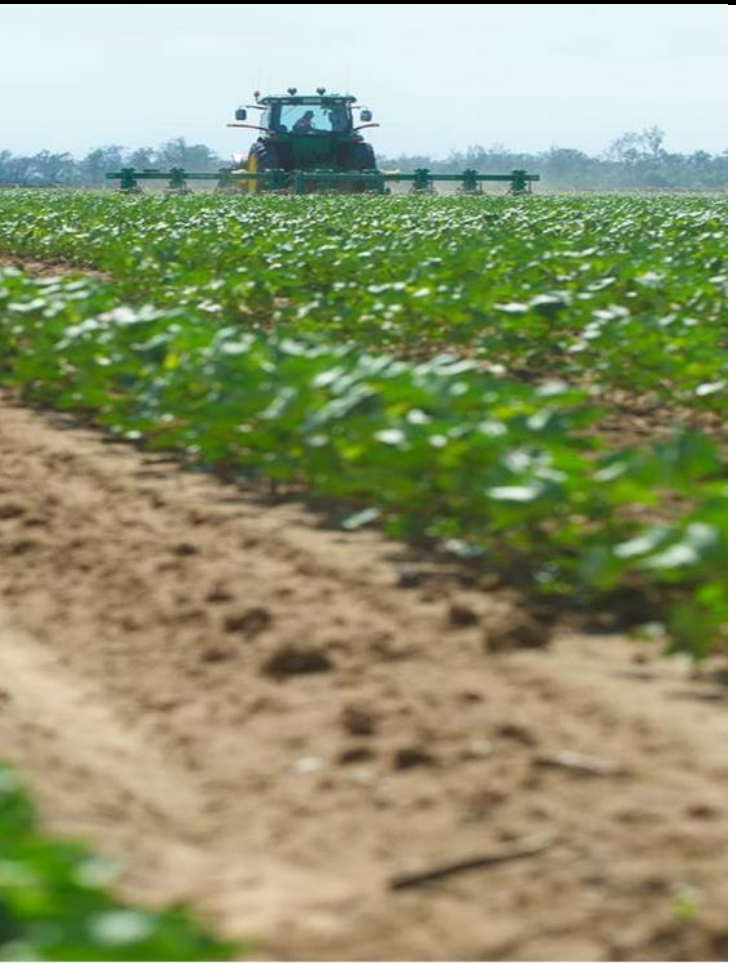

- Safety moment
- Duleen Kupunn Field Development Plan
- Questions raised
- Deviated wells
- Break
- Subsidence
- Q&A
- Next steps




About Arrow

- Arrow is an integrated energy company owned 50/50 by Shell and PetroChina
  - 15,000km^2 of tenements over the Surat and Bowen Basins in Queensland
  - ~1,450 gas wells currently
  - ~6,500 petajoules of 2P gas reserves to date
- Existing domestic gas operations:
  - five operating gas fields - Tipton, Daandine, Kogan, Stratheden (Surat Basin) and Moranbah Gas Project (50/50 with AGL - Bowen Basin)
  - supply gas to operators of power stations - Braemar 1, Braemar 2 (100% Arrow owned), Yabulu, Daandine, Moranbah, Swanbank
  - first produced from the Bowen Basin in 2004
  - generation capacity = supply for ~800,000 Queensland homes
- Surat Gas Project (SGP) is underpinned by the largest gas sales agreement on the east coast of Australia, with the Shell-QGC joint venture:
  - in April 2020, Shareholders made a Final Investment Decision (FID) for phase 1 of the 27-year project
  - Arrow sanctioned construction to start in 2020
  - peak construction - 2021-2025; first gas - 2021

Why are we here today



Since May 2019, we've engaged with landholders in the Kupunn area to inform field development plans.

We've met through shed meetings, webinars, site visits, individual and group correspondence.

Today we will:

- present the Duleen Kupunn field development plan
- address previous questions through the Area Wide Planning process
- provide an update on our deviated drilling process
- provide an update on our subsidence monitoring activities
- Q&A
- explain next steps and timeframes.




- **Safety moment**
- Duleen Kupunn Field Development Plan
- Questions raised
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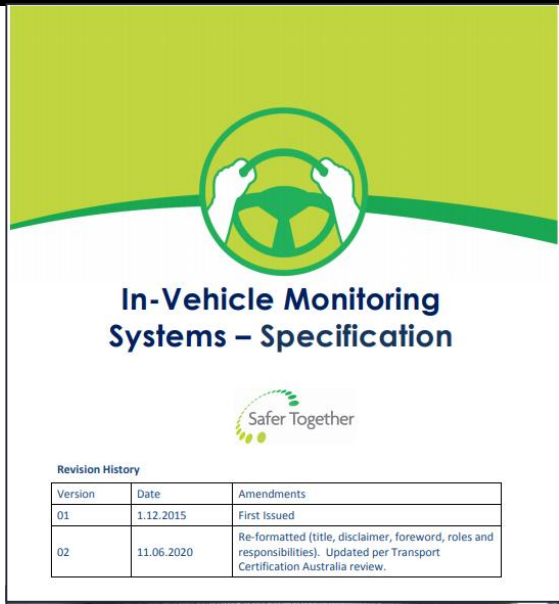
- **Break**
- **Subsidence**
- **Q&A**
- **Next steps**




Safety moment - In-Vehicle Monitoring System (IVMS)

- The use of In-Vehicle Monitoring Systems (IVMS) is a requirement of the ‘Safer Together’ initiative
- All light and heavy vehicles must be fitted with IVMS hardware that includes GPS capability
- Arrow employees and contractors are issued with a unique driver ID plug
- IVMS system monitors and records:
  - speed
  - fatigue
  - driver behaviours (e.g. harsh braking, cornering or accelerating)
  - use of 4WD on unsealed roads
  - use of seatbelts
- Violation notifications are automatically sent to line managers



In-Vehicle Monitoring Systems – Specification

Safer Together

Revision History

Version	Date	Amendments
01	1.12.2015	First Issued
02	11.06.2020	Re-formatted (title, disclaimer, foreword, roles and responsibilities). Updated per Transport Certification Australia review.




Safety moment | **Duleen Kupunn Field Development Plan** | Questions raised | Deviated wells | Break | Subsidence | Q&A | Next steps




Arrow's field development process

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INTERNAL ARROW

Concept field development

Field layout is designed for each property including:

- location and types of wells
- deviated well trajectories
- gathering lines
- construction requirements

AREA WIDE PLANNING

Understand local farming practices and share concept plan with landholders in the area

DESIGN

FEEDBACK

Area wide field development plan shared with landholders

Entry Notices provided for preliminary activities including surveys and subterranean entry

Works notifications sent out before site activities commence

INDIVIDUAL LANDHOLDERS

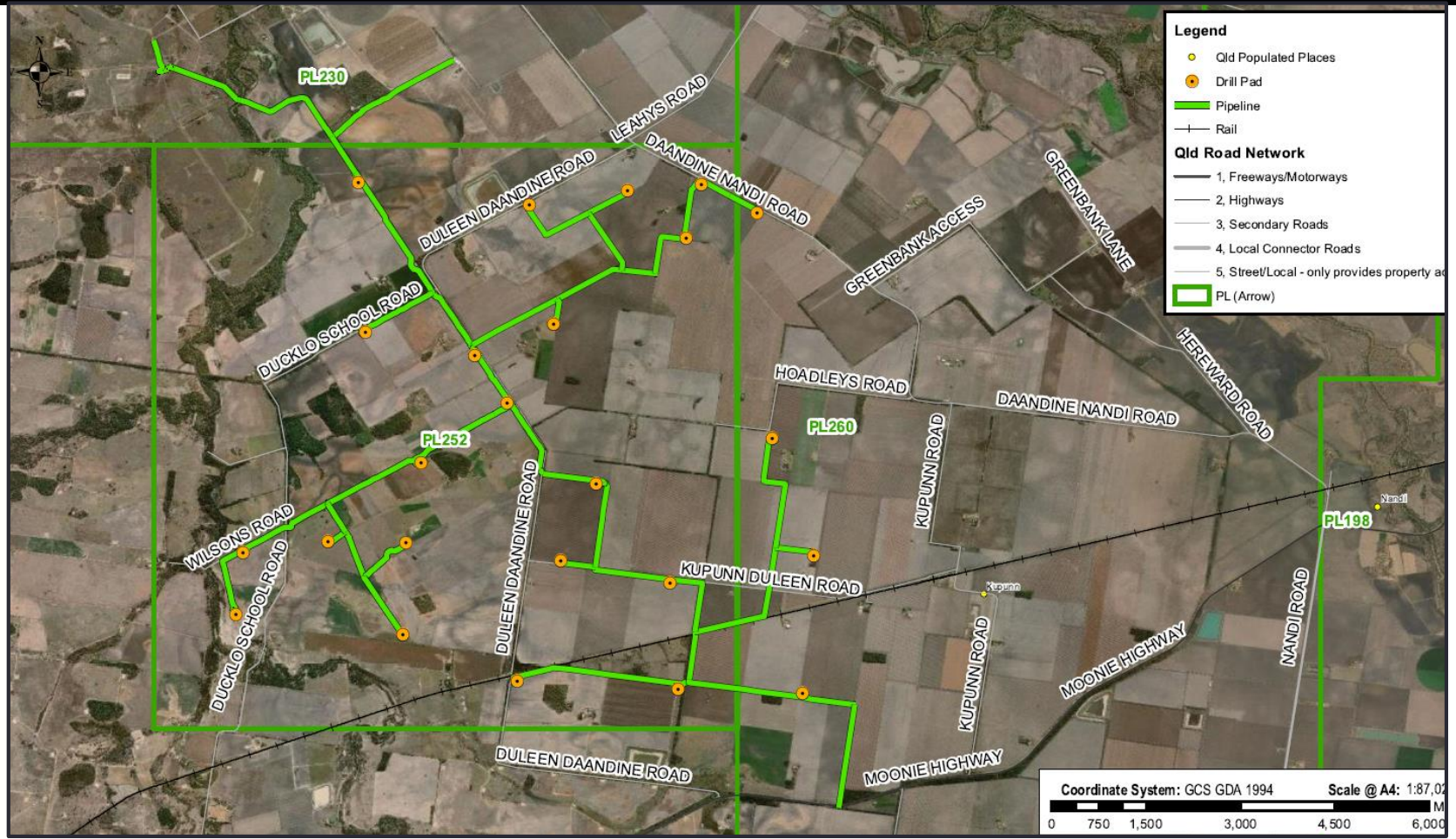
Individual landholder discussions about potential locations for surface infrastructure

Discussion with landholders about draft field layout and deviated well trajectories

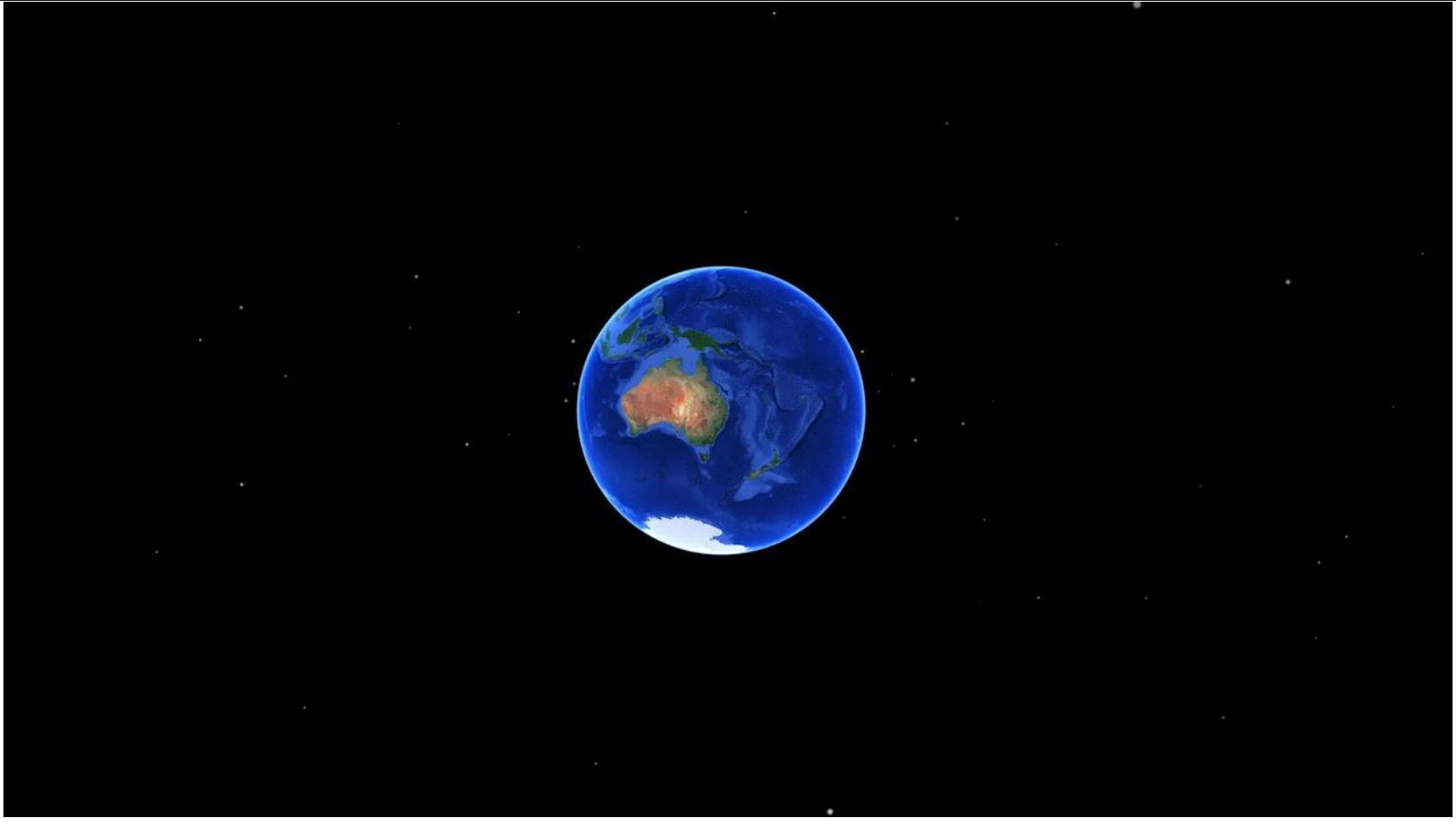
Field layout is finalised and CCA negotiations commence

Arrows field development process

Field development plan



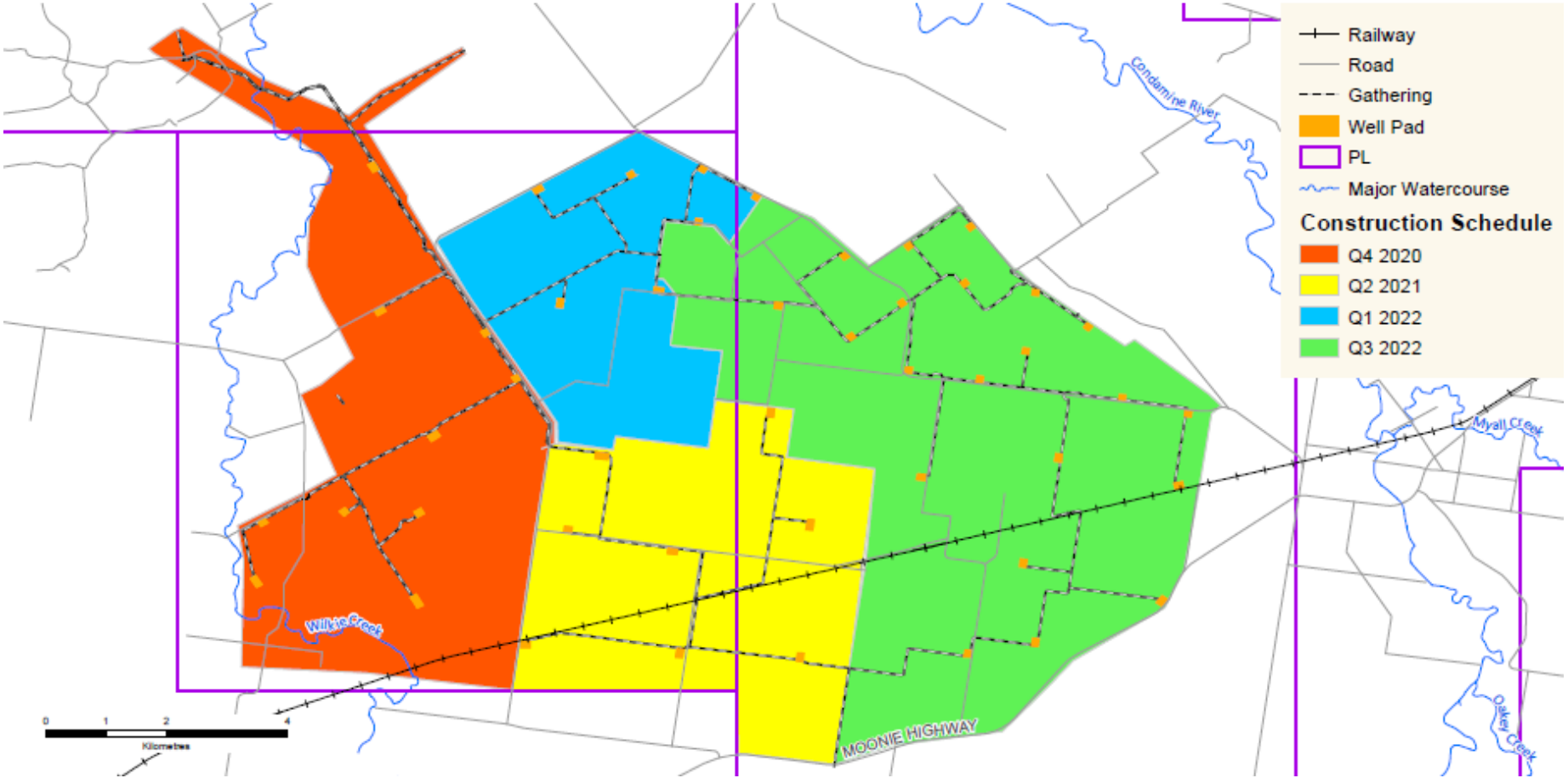
Deviated drilling



Deviated drilling - history

- Deviated wells are a critical part of Arrow's ability to coexist with the agricultural industry by significantly reducing the surface impacts of gas development on agricultural land
- Multi-well pads and deviated wells provide greater flexibility and opportunity to accommodate farming systems including through the placement of well-pads, which minimise impacts on land use
- Arrow's deviated drilling practices have been shaped by engagement with key stakeholders over the last 8 years
- A traditional CSG field plan consists of single vertical wells approx. 800m apart
- The use of deviated wells allows up to 8 wells on a single well pad with the flexibility to be located on the boundaries of properties and up to 1.5km apart
- Our initial field development planning anticipates that over the 27-year life of the Surat Gas Project, around 65% of wells are likely to be deviated

Kupunn drilling and construction schedule



Phases of wellsite construction

Well pad cleared and levelled	4-8 days	☀
Drilling	4-7 days	☀ ☾
Installation of well surface facilities	30-90 days	☀
Installation of water pump	5 days per well	☀ ☾
Well maintenance (workovers)	3-6 days per well	☀ ☾

- Typical construction workforce numbers per site:
  - site prep: ~8 workers
  - drilling: ~ 15 workers
  - surface facility construction: ~10 workers
- Construction workforce accommodation:
  - existing Dalby accommodation (camp and local housing)
  - short-term ~30 person mobile camps for drilling contractors:
    - Stratheden (new)
    - Tipton, Daandine, Theten (existing)
- Lighting required short-term during 24-hour drilling:
  - expectation that contractors will orientate lighting to minimise light spill

Phases of pipeline construction

- ~80 gathering construction workers on site at any one time
- ~200 gathering construction staff in the area from next month covering numerous work-fronts
- Construction timeframes vary
- Construction workforce housed in Dalby in existing accommodation

Right of way cleared and levelled, topsoil stockpiled	☀
Pipeline is laid out and welded in a continuous string	☀
The trench is excavated to at least 750mm to top of pipe, the pipe is lowered into the trench	☀
Above ground infrastructure (high-point vents, low point drains) are constructed	☀
The pipeline is pressure tested (road closures may be necessary)	☀ ☾
The right of way is rehabilitated	☀
During operations, maintenance will be required from time to time	☀

Ducklo area wells



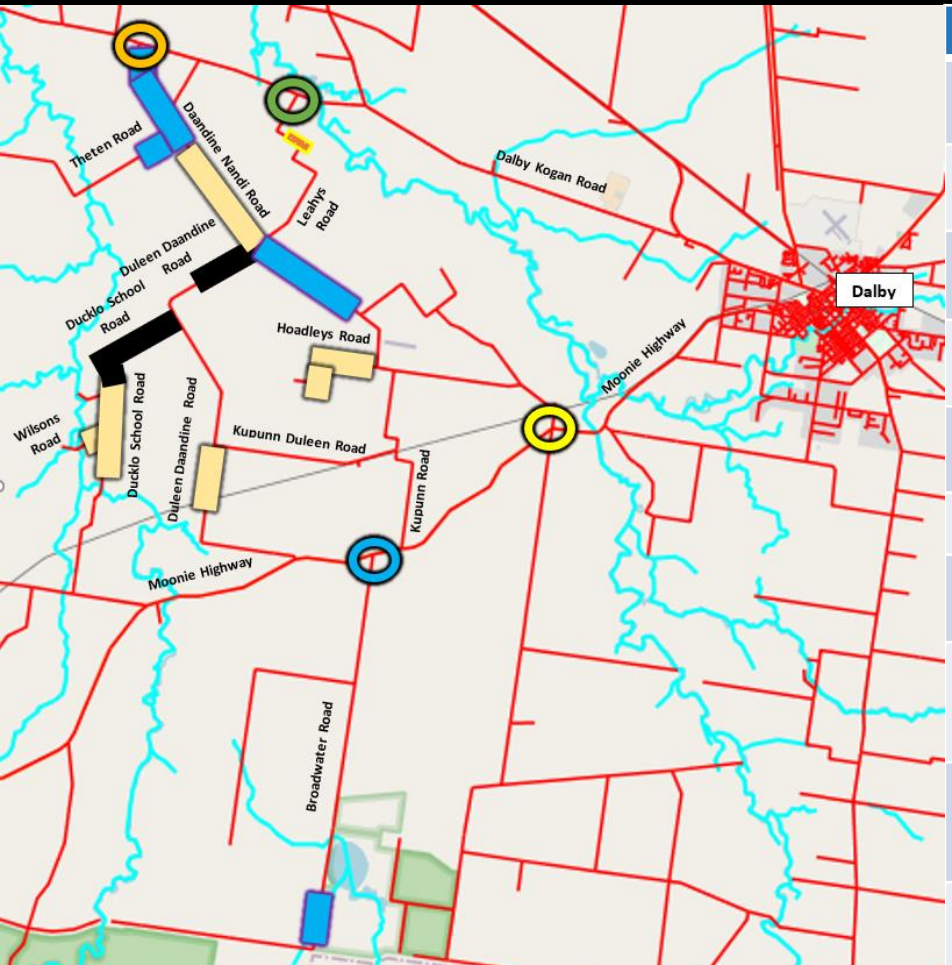

Safety moment | Duleen Kupunn Field Development Plan | **Questions raised** | Deviated wells | Break | Subsidence | Q&A | Next steps




Questions raised through Area Wide Planning

Issue	Outcomes	Status
Road impacts and maintenance	• Traffic Impact Assessments with Council and State Government • Road Management Strategy to identify road management requirements • Road upgrades and maintenance activities	Complete Complete Underway
Flexibility on farming systems and future farm development plans	• Arrow works with landholders to understand current and future farming systems; Arrow's infrastructure is designed accordingly where possible • Where we do not have landholder input, we apply our understanding of common farming practices • Multi-well pads and deviated wells provide greater flexibility and opportunity to accommodate farming systems through placement of well-pads, which minimise impacts on land use	Ongoing Ongoing
Safety and amenity	• Arrow's 12 Coexistence Commitments and Land Access Rules	Ongoing
Rehabilitation and financial assurance	• Arrow will comply with Government-mandated rehabilitation expectations, tenure conditions and environmental approvals • The Environmental Authority that applies to the Kupunn area (Daandine Expansion EA) presently holds ~$64m of financial assurance in the form of bank guarantees	Ongoing Ongoing
In-fill wells	• Arrow has no intention to drill additional 'in-fill' wells	Complete
Brine management	• Salt brine may be crystallised and safely stored in a landfill • No brine/salt treatment, storage or disposal on IFL	Ongoing

Road upgrade map



Location / works	Works	Start date
Various locations	Grading, repairs and maintenance	December 2020
Section of Duleen Daandine Road	Upgrade and sealing works	January 2021 (sealing ~20 May)
Moonie Highway / Daandine Nandi Road	Intersection upgrades	Early May 2021
Moonie Highway / Broadwater Road	Intersection upgrades	End May 2021
Section of Ducklo School Road	Upgrade and sealing works	End May 2021
Section of Leahy's Road	Partial sealing	End May 2021
Dalby Kogan Road / Daandine Nandi Road	Intersection upgrades	Early June 2021
Sections of Daandine Nandi Road and Theten Road	Upgrade and sealing works	July 2021 (TBC)
Dalby Kogan Road / Leahy's Road	Intersection upgrades	August 2021 (TBC)
Section of Broadwater Road	Upgrade and sealing works	August 2021 (TBC)

Questions raised through Area Wide Planning

Issue	Outcomes	Status
Road impacts and maintenance	• Traffic Impact Assessments with Council and State Government • Road Management Strategy to identify road management requirements • Road upgrades and maintenance activities	Complete Complete Underway
Flexibility on farming systems and future farm development plans	• Arrow works with landholders to understand current and future farming systems; Arrow's infrastructure is designed accordingly where possible • Where we do not have landholder input, we apply our understanding of common farming practices • Multi-well pads and deviated wells provide greater flexibility and opportunity to accommodate farming systems through placement of well-pads, which minimise impacts on land use	Ongoing Ongoing
Safety and amenity	• Arrow's 12 Coexistence Commitments and Land Access Rules	Ongoing
Rehabilitation and financial assurance	• Arrow will comply with Government-mandated rehabilitation expectations, tenure conditions and environmental approvals • The Environmental Authority that applies to the Kupunn area (Daandine Expansion EA) presently hold ~$64m of financial assurance in the form of bank guarantees	Ongoing Ongoing
In-fill wells	• Arrow has no intention to drill additional "infill" wells	Complete
Brine management	• Salt brine may be crystallised and safely stored in a landfill • No brine/salt treatment, storage or disposal on IFL	Ongoing

Questions raised through Area Wide Planning

Issue	Outcomes	Status
Groundwater impacts	• Arrow complies with make good obligations as prescribed in the *Queensland Water Act 2000,* and conditions of approval granted under the Commonwealth *Environmental Protection and Biodiversity Conservation Act 1999*	Ongoing
Area-wide planning and deviated wells	• **Further information on deviated wells to follow** • Deviated wells minimise surface disturbance and enable greater coexistence • Following landholder feedback, Arrow will improve the area wide planning process and provide increased visibility with adjoining landowners regarding proposed deviated wells that traverse property boundaries	Ongoing
Insurance and liability	• GFCQ-established working group reached agreement on an indemnity clause to landholders who host CSG infrastructure will have ongoing farm public liability coverage • Where it is required, Arrow will provide the indemnity clause in our CCA • *Post-rehabilitation landholder liability	Complete Complete *Discussion with regulator ongoing
Subsidence	• **Further information to follow**	Ongoing

***Information pack amended**
17 May 2021




Safety moment | Duleen Kupunn Field Development Plan | Questions raised | **Deviated wells** | Break | Subsidence | Q&A | Next steps




Deviated wells

- All existing landholders with deviated wells at depth beneath their property have now been advised
- Arrow considers that the location, trajectory and depth of any deviated wells that enter neighbouring private land is such that they will have no impact or only minor impact on the business or land use of the property. These wells typically enter neighbouring properties at a depth greater than 200m below the surface
- Under special circumstances in the Act, a well may require a deed, regardless of level of impact on the property
- This may be required where a property is less than 100ha and intensively farmed or broadacre agriculture; or a bio-organic farming operation
- If a landholder advises us that their insurer has concerns regarding deviated wells deep beneath properties, Arrow would be prepared to provide a suitable agreement to extend protection to landowners

Deviated drilling - process going forward

Going forward, Arrow will…

Provide visibility of our initial proposed field layout, including the location of deviated wells that may traverse into neighbouring land.

Consult with landowners about their own current and future infrastructure and operational plans.

Provide updates to landowners on any changes to the location or trajectory of deviated wells as a result of:

- AWP
- engineering design changes
- any relevant changes once CCA is finalised.

Once the well layout and CCAs are finalised, issue of an Entry Notice to the owner and occupier of private land into which a deviated wells will traverse, at least 10 business days prior to the commence of drilling of the well.

Once drilling of the deviated well is completed, provide a tailored map to the relevant landholder with details of the final as-built location, trajectory and well depth

BREAK




Safety moment | Field development plan | Questions raised | Deviated wells | Break | **Subsidence** | Q&A | Next steps

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Updated Subsidence Management Framework

14/05/2021

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Items to discuss

1. Monitoring
   a. Definitions
   b. Monitoring techniques
   c. WMMP obligations
2. Analysis of historical observations
   a. Purpose
   b. Existing slope on cultivation
   c. Ground movement with distance from wells
   d. Workflow
   e. Ground movement with distance and age of wells
   f. Implications for subsidence management
3. Completed and ongoing works

1a Definitions

Absolute elevation; The elevation of a point relative to a reference e.g. the Australian Height Datum

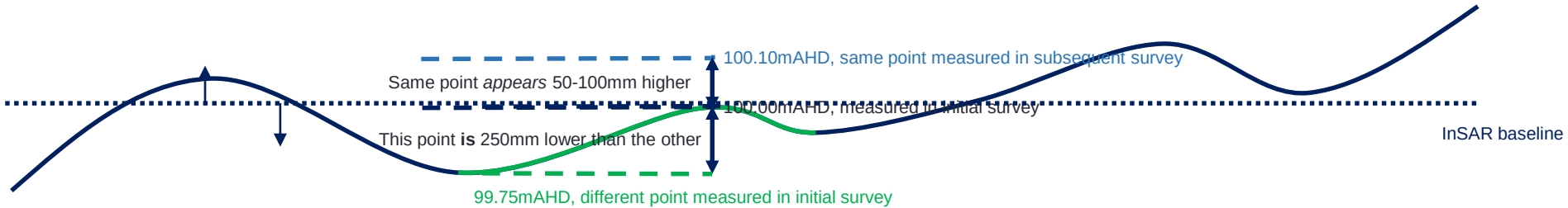
Absolute accuracy; How accurately we can measure the absolute elevation of the same point (50-100mm) between surveys

Relative elevation; The elevation of a point relative to other points in same survey

Relative accuracy; How accurately we can measure relative elevation (mm-scale with LiDAR or similar)

Digital Elevation Model; (DEM) representation of topography as generated from a survey (e.g. LiDAR)

Relative change in elevation; Change in elevation of individual points compared to previous measurements from a baseline (mm-scale with InSAR)



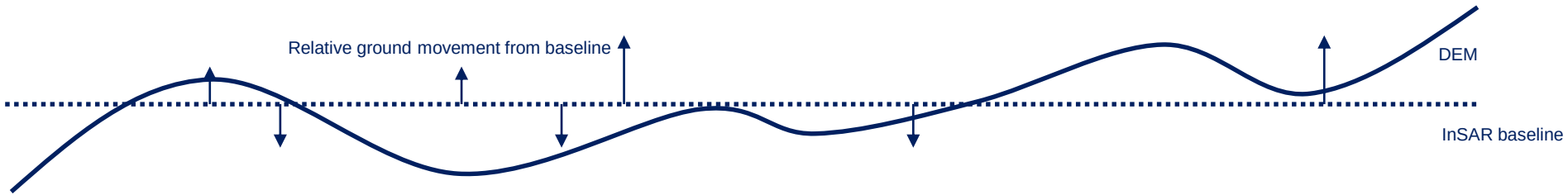
1a Example of Definitions

1b InSAR monitoring

Pros; InSAR **can measure relative change in elevation very accurately** (mm scale) from a specified baseline

Cons; Less concentrated data presented over cultivation

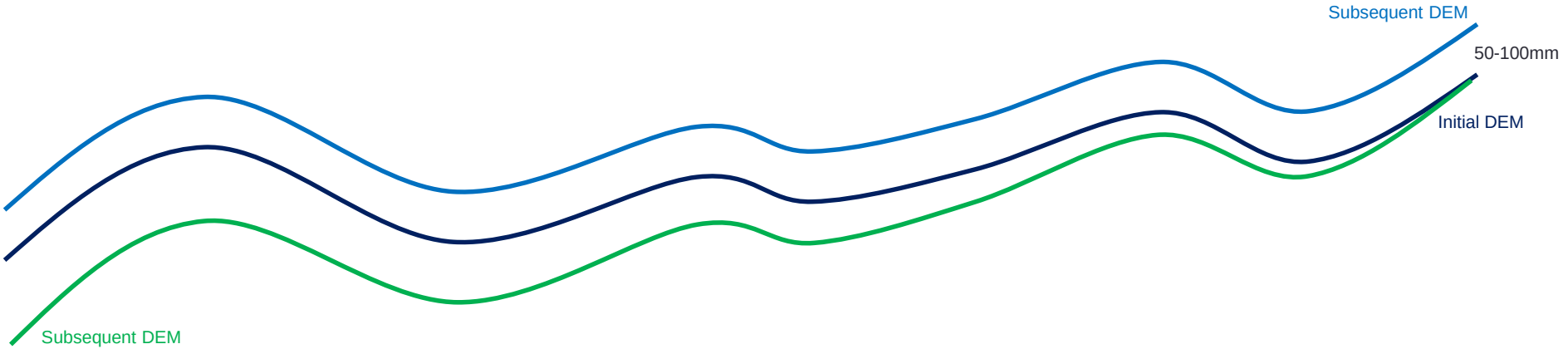
Baseline; Date from which relative change in elevation measured e.g. commencement of SGP CSG water production. Not measuring absolute elevation



1b LiDAR monitoring

Pros; LiDAR has very high ‘relative accuracy’ (mm-scale) and can therefore be used to generate a DEM, can cover large areas efficiently
Cons; Absolute accuracy in order of 50-100mm, comparison of absolute elevations between surveys cannot be used to identify CSG-induced ground movement

Gradient change; LiDAR is **well suited for identifying changes in gradient**

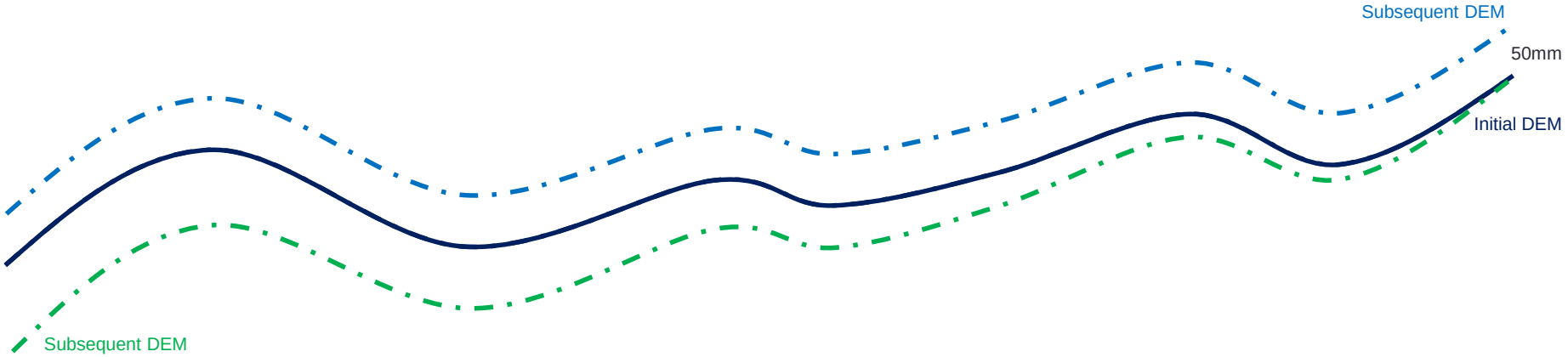


1b RTK monitoring

Pros; RTK has very high ‘relative accuracy’, **can be used to generate a DEM at farm scale**, collected frequently

Cons; Absolute accuracy in order of 50mm, comparison of absolute elevations between surveys cannot be used to identify CSG-induced ground movement, **not regional, doesn’t cover entire surface**, influenced by factors such as; tyre pressure, weight of vehicle, accuracy in fixing the base location, system setup, etc.

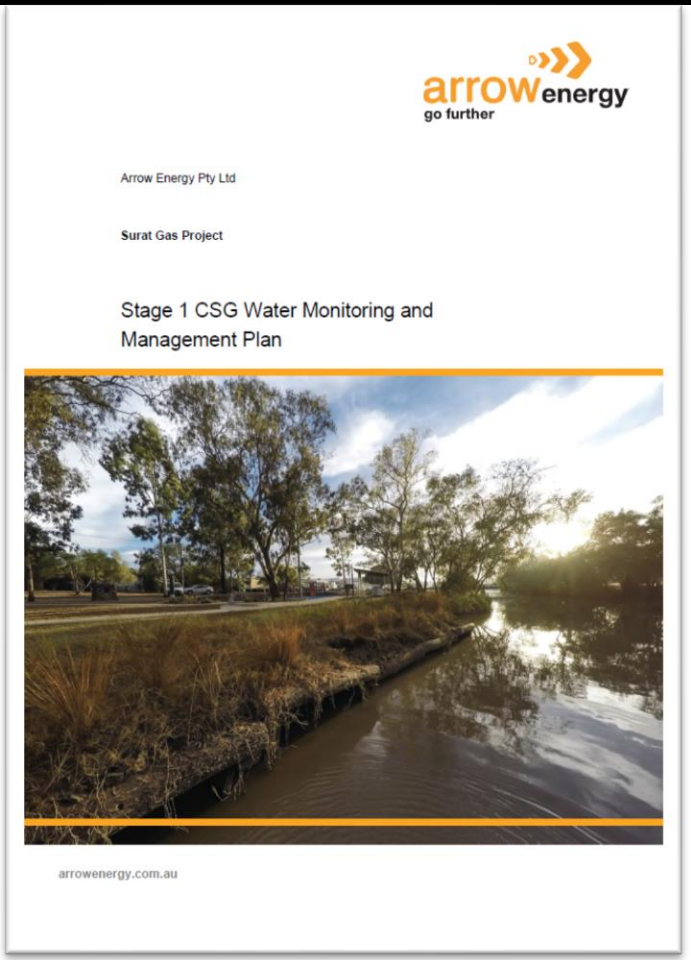
Gradient change; RTK is **reasonably well suited for identifying changes in gradient**



1b Monitoring techniques summary

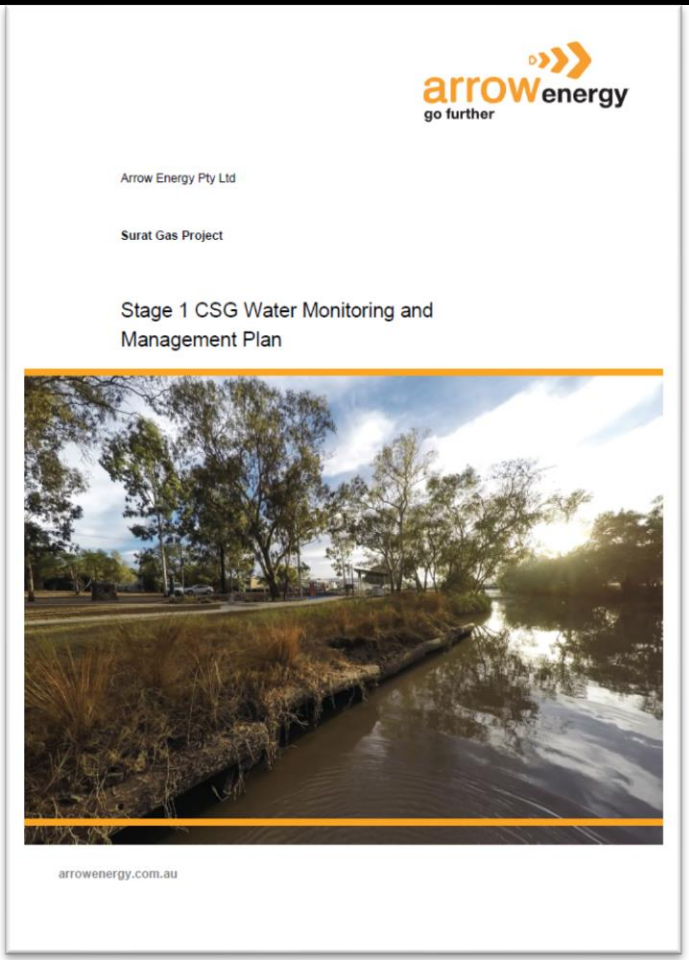
- Approach to monitoring relies on techniques with the highest degree of accuracy i.e.:
  - Relative change in elevation (i.e. InSAR), and
  - Changes in relative gradient (i.e. LiDAR) when undertaking further investigation.
- We are not aware of any survey techniques which can identify CSG induced subsidence by identifying changes in **absolute elevation** (in a repeatable manner and on a regional scale) given:
  - Absolute accuracy of regional surveys in order of 50-100mm,
  - Magnitude of ground movement in order of 5-25mm/km, and
  - Natural variation of up to 200mm.

1c Arrow's WMMP obligations



- The WMMP approval Condition 13g requires:
  - A program to monitor subsidence impacts from the action, including trigger thresholds and reporting of monitoring results in annual reporting required by condition 28.
  - If trigger thresholds are exceeded, the approval holder must develop and implement an action plan to address impacts within 90 calendar days of a trigger threshold being exceeded.
- Arrow's shareholders announced a financial investment decision for phase one of the project on 17 April 2020, with construction commencing 22 October 2020.
- Obligations in the WMMP were triggered once construction started and apply to activities undertaken as part of that project.
- The first annual report will be submitted ~15 months after construction commences (22 January 2022).

1c Arrow's WMMP obligations



- WMMP – Subsidence monitoring program:
  - Three tiers.
  - Exceedance of threshold for each tier triggers further action.
  - Tiers rely on most accurate attributes of monitoring techniques

	Tier	Predominant technique	Attribute
1	Screening level	InSAR	Relative change in elevation
2	Investigation level	Survey (e.g. LiDAR)	Change in gradient
3	Trigger threshold	Various	Asset specific assessment

1c Arrow's WMMP obligations: Screening level

- Screening level involves analysis (6 monthly) of InSAR data in 1km by 1km blocks across Arrow tenure:
  - Consistent with industry standard
  - In some respects is more stringent
  - Was peer reviewed and endorsed by Ministerially-approved water resources expert
  - Well suited to identify ground movement at regional scale.
  - Based on **relative change in elevation.**
  - Does not require 100% coverage across all surfaces.
  - Triggers more detailed investigation.

Approved WMMP wording

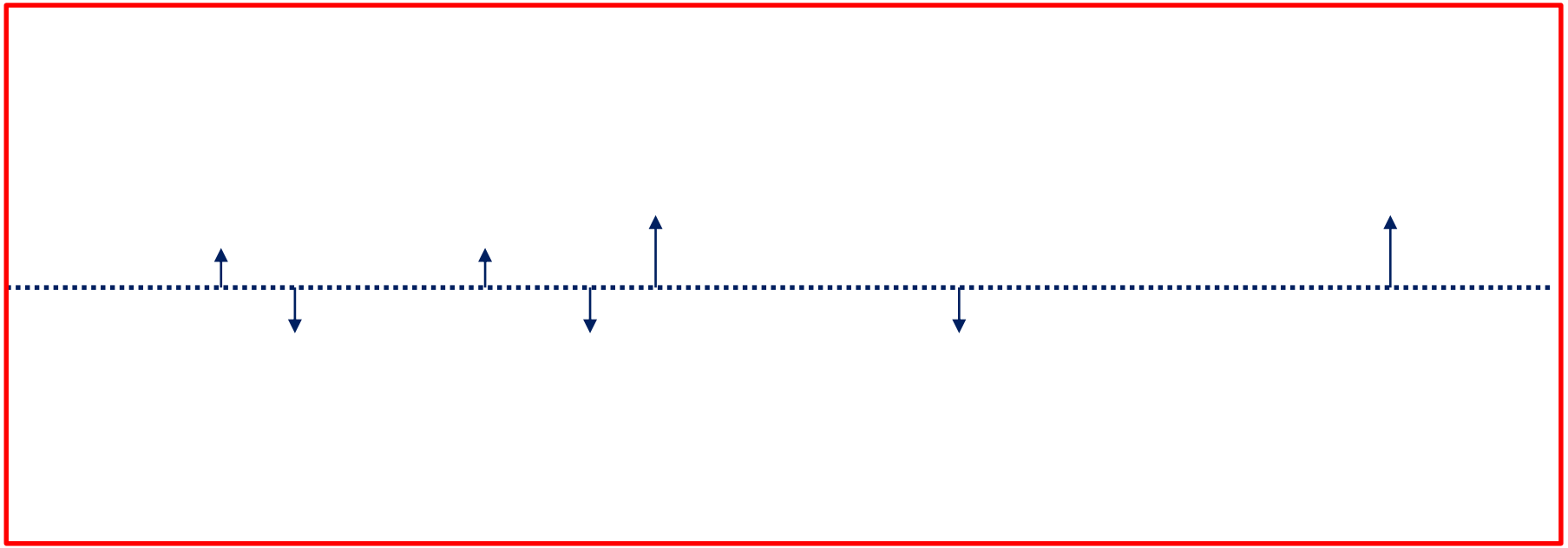
Item	Description	Criteria	Relevant assets	Basis for selection / comment
Screening level	Settlement rate	8 mm/year (for >50% of sampling points in 1 km by 1 km block)	All natural features, man-made features and built infrastructure	Areas where this criterion is exceeded will be subject to investigation of subsidence (refer Appendix K).
Investigation levels	Gradient change	0.03 % (300 mm per 1,000 m)	Irrigation system (laser levelled)	Based upon half the slope of minimum grades recommended by the Cotton Research and Development Corporation for furrow irrigation. Areas where this criterion is exceeded will be subject to investigation of subsidence (refer Appendix K), including review of laser levelling practices.

1c Arrow's WMMP obligations: InSAR monitoring

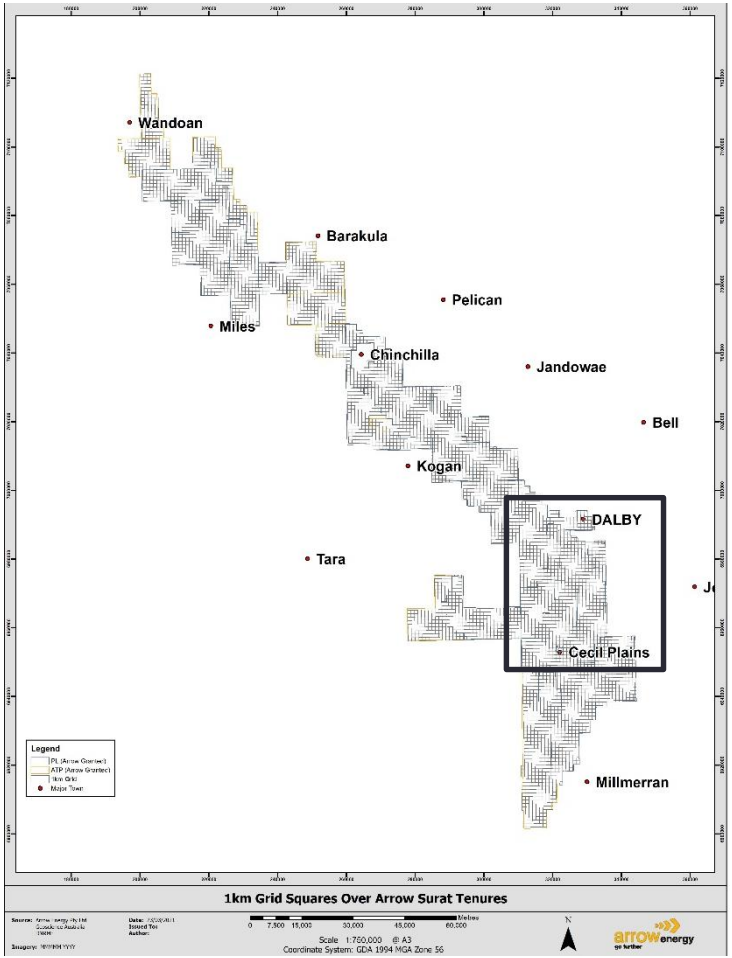
Pros; InSAR can measure relative change in elevation very accurately (mm scale) from a specified baseline

Cons; Not measuring elevation, less concentrated data presented over cultivation

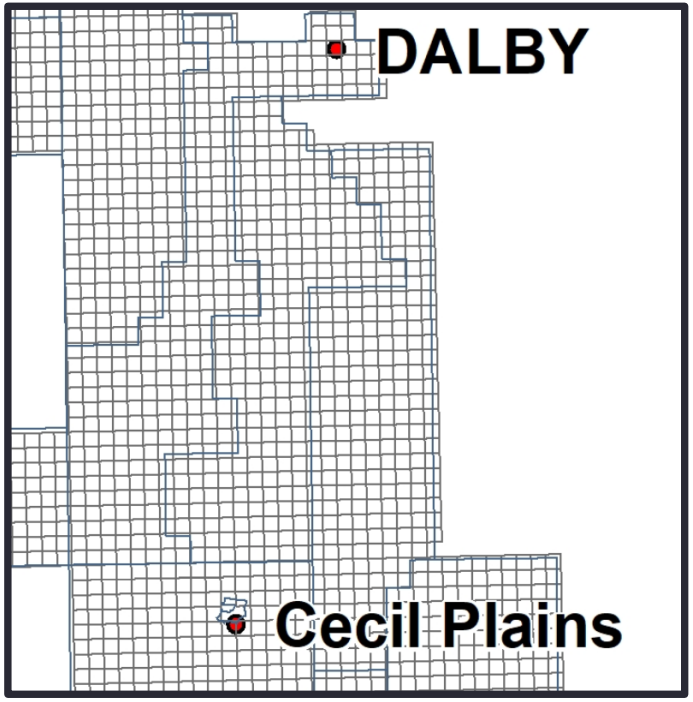
Screening level; >50% of InSAR points in a 1km-by-1km area exceed 8mm/yr in downward movement



1c Arrow's WMMP obligations: screening level



- 1km by 1km blocks across Arrow tenure



1c Arrow's WMMP obligations: Investigation level

- Investigation level involves evaluation of **change in gradient**:
  - InSAR not used exclusively for this.
  - Process recognizes that ground movement can be caused by a range of factors.
  - Amendment submitted 20 April:
    - To cover dryland cropping.
    - Include criteria for slopes <0.06%.
    - Describe survey methods (e.g. LiDAR) where InSAR data presented for <50% of property, and
    - Investigation level assessment must be undertaken where no InSAR data

Approved WMMP wording

Item	Description	Criteria	Relevant assets	Basis for selection / comment
Screening level	Settlement rate	8 mm/year (for >50% of sampling points in 1 km by 1 km block)	All natural features, man-made features and built infrastructure	Areas where this criterion is exceeded will be subject to investigation of subsidence (refer Appendix K).
Investigation levels	Gradient change	0.03 % (300 mm per 1,000 m)	Irrigation system (laser levelled)	Based upon half the slope of minimum grades recommended by the Cotton Research and Development Corporation for furrow irrigation. Areas where this criterion is exceeded will be subject to investigation of subsidence (refer Appendix K), including review of laser levelling practices.

1 Arrow's WMMP obligations: Trigger threshold

- Trigger threshold evaluated where Investigation level exceeded:
  - Additional on ground investigations carried out with conventional surveys.
  - Results of the survey assessed against asset-specific thresholds.

Approved WMMP wording

Trigger threshold	Outcome of site specific monitoring using conventional survey and review of risk to asset.	Individual threshold based on the local conditions	Irrigation system, structure or watercourse	• Site specific assessment based upon conventional survey of identified asset. In the case of potential impacts on structures within populated areas the assessment will be based upon selected structures considered to be most vulnerable.

  - Amendment submitted (20 April) to describe Trigger threshold evaluation will include:
    - Slope and drainage which will be evaluated to assess whether CSG has contributed to subsidence.
    - Consideration of whether subsidence has caused a loss to productivity (including information which will be required).
- Arrow must develop and implement an action plan to address impacts within 90 calendar days of a trigger threshold being exceeded.

1 Monitoring; summary

- Ground movement monitoring relies on techniques with the highest degree of accuracy
- Comparison of **absolute elevations** (which relies on **absolute accuracy**) isn't used
- WMMP has a 3-tier approach to monitoring subsidence
- Screening level identifies **relative change in elevation**; InSAR ideally suited for this
- Investigation level assessment (when Screening level exceeded) evaluates changes in slope:
  - may include LiDAR which has a high **relative accuracy**,
  - is suitable for determining drainage, and
  - is efficiently collected over large areas in a consistent manner

1 Monitoring; summary

- LiDAR has similar properties to RTK methods, which may be collected more frequently on a smaller scale
- Arrow has submitted an amendment to the WMMP, including method for identification of impacts, and
- Arrow must address CSG-induced subsidence which causes impact.

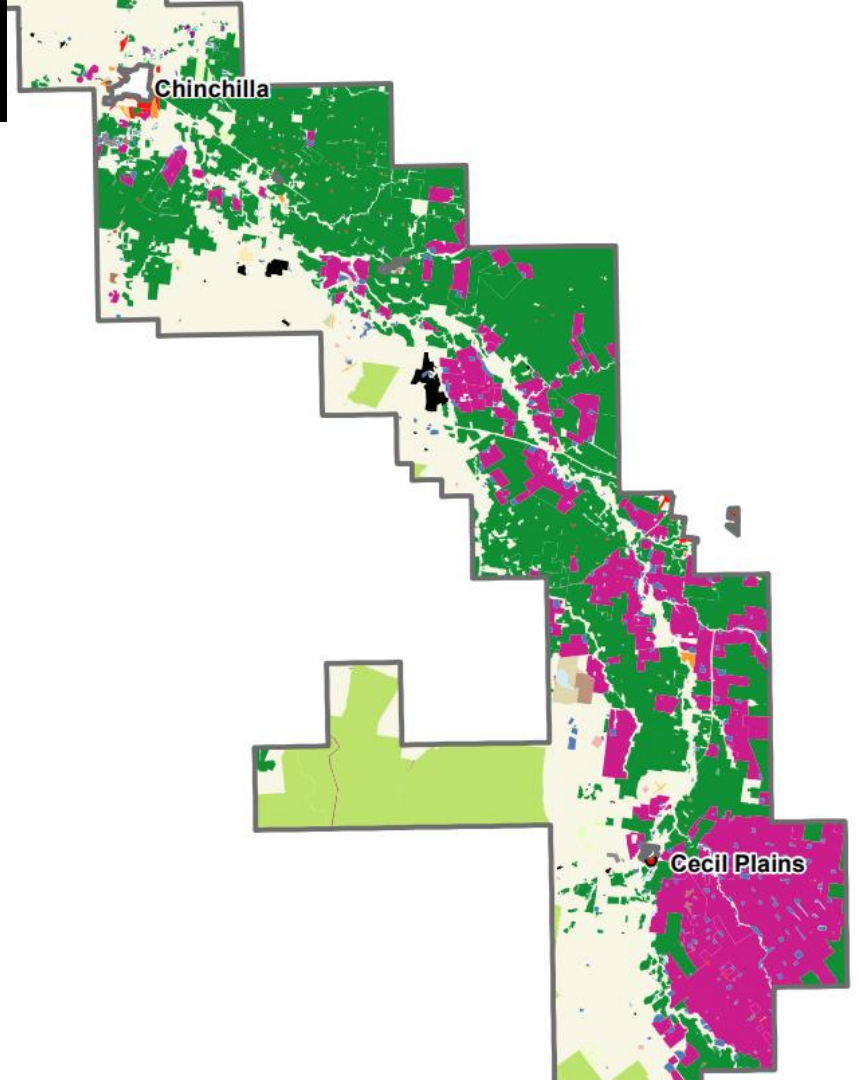
Analysis of historical observations

2a Analysis of historical observations; purpose

- Further analysis of historical InSAR data was undertaken.
- Previous analysis considered ALOS (in the SREIS) and Radarsat (in the Stage 1 WMMP).
- Historical InSAR data was analysed to:
  - Inform updates to subsidence model,
  - Inform extent of further monitoring (i.e. distances from CSG wells in which CSG-induced ground movement could reasonably occur), and
  - Review understanding of likely magnitude of CSG-induced ground movement.

2b Analysis of historical observations; existing slope on cultivation

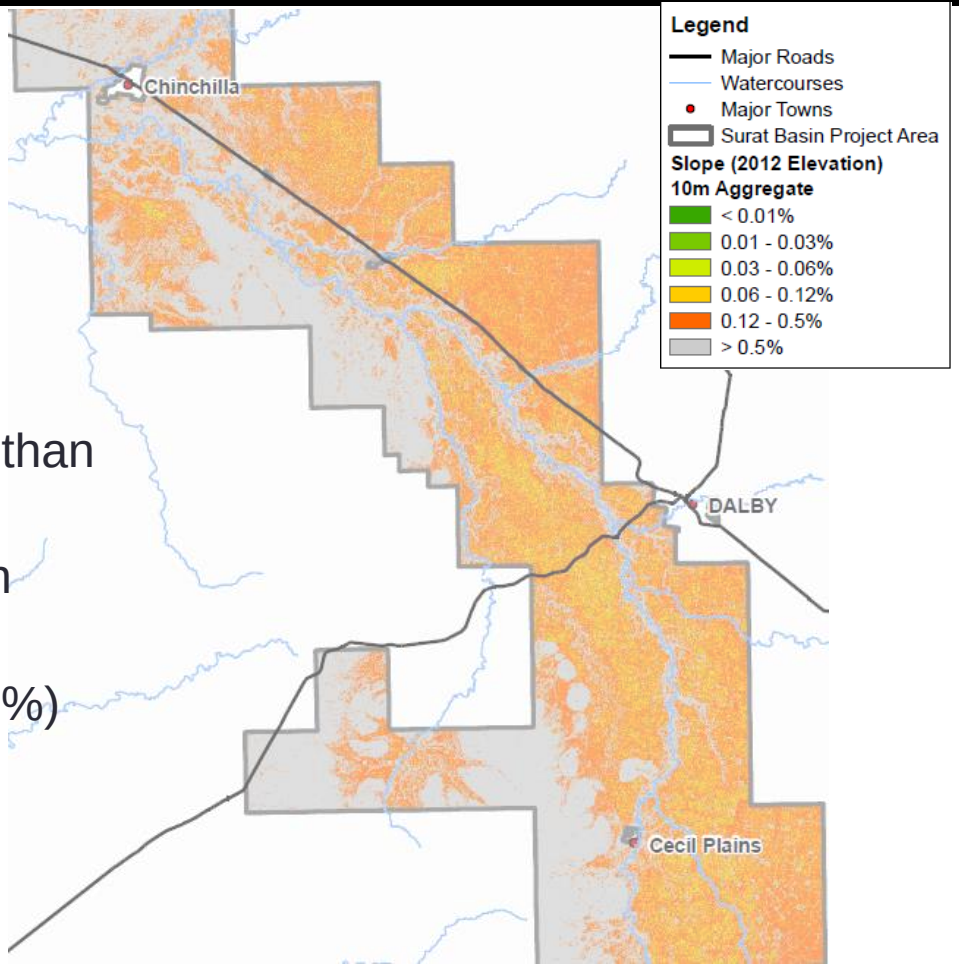
- Cultivation:
  - Irrigated (11% of tenure, pink)
  - Dry land (30% of tenure, dark green)
  - Some InSAR data is presented on cultivated areas (increased area of coverage)
  - Significant InSAR data presented on other areas



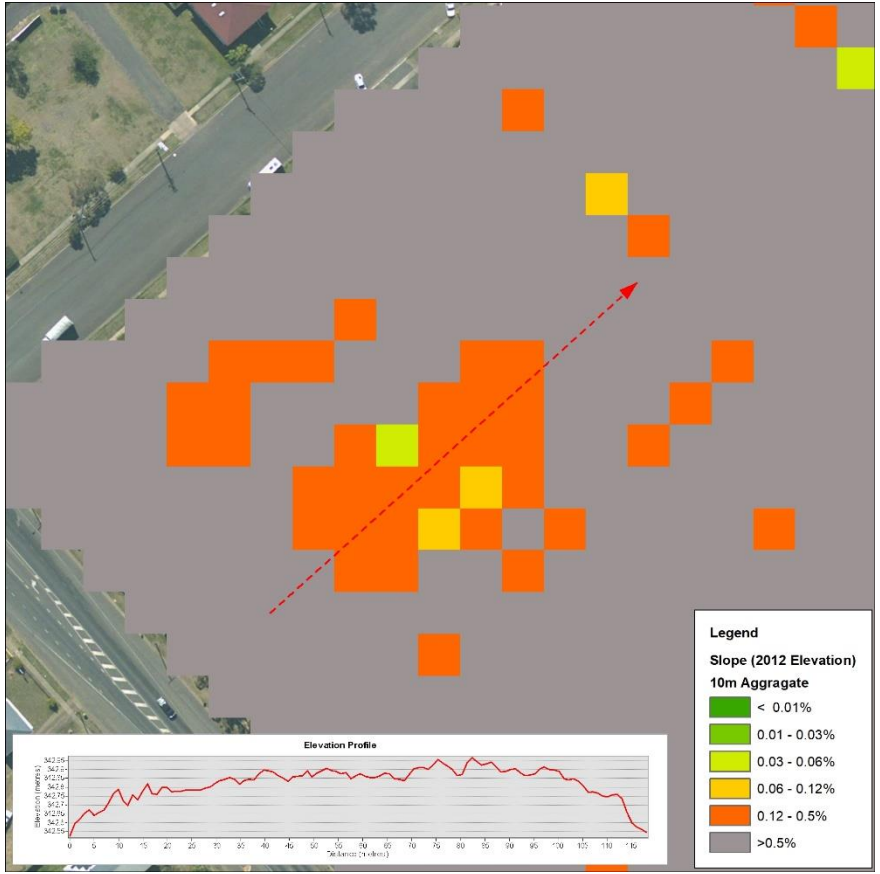
2b Analysis of historical observations; existing slope on cultivation

2012 LiDAR						
	<0.01%	0.01-0.03%	0.03-0.06%	0.06-0.12%	0.12-0.5%	>0.5%
Dryland	0.10%	1.00%	3.30%	11.00%	47.50%	37.00%
Irrigation	0.20%	1.70%	5.60%	18.50%	58.70%	15.30%
2014 LiDAR						
	<0.01%	0.01-0.03%	0.03-0.06%	0.06-0.12%	0.12-0.5%	>0.5%
Dryland	0.22%	1.70%	5.19%	15.08%	48.04%	29.78%
Irrigation	0.26%	2.05%	6.76%	21.40%	52.71%	16.83%

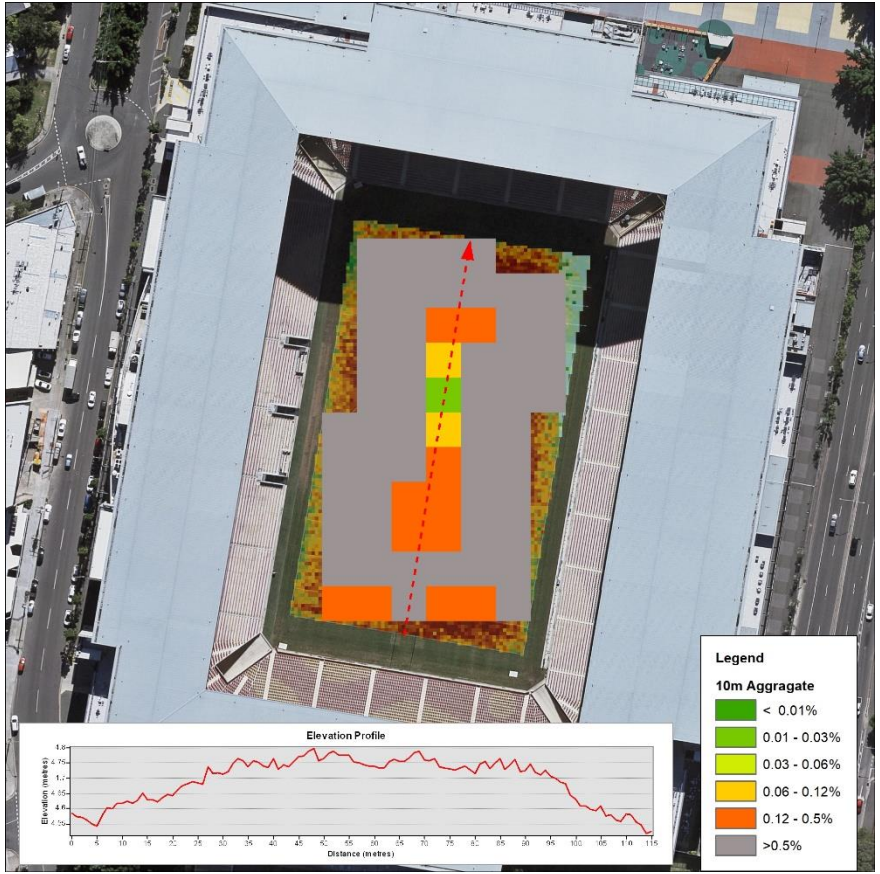
- 2014 LiDAR covered a smaller area than 2012
- 1.4% to 2.0% of slopes on cultivation <300mm/km
- Majority of cultivation (92.3% to 94.6%) >600mm/km



2b Existing slope; example of Dalby rugby league field



2b Existing slope; example of Suncorp Stadium



2c Analysis of historical observations; ground movement with distance from wells

- 3 satellites provided data since 2006:
  - ALOS-1 (2006 - 2011)
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  - Sentinel (2015 -)
- InSAR satellites collect data across entirety of tenure.
- Less-dense data is presented (after processing) on cultivated areas.
- Use of Sentinel satellite and new processing algorithms have resulted in ~85% more data being presented
- All data can be analysed to evaluate historical ground movement
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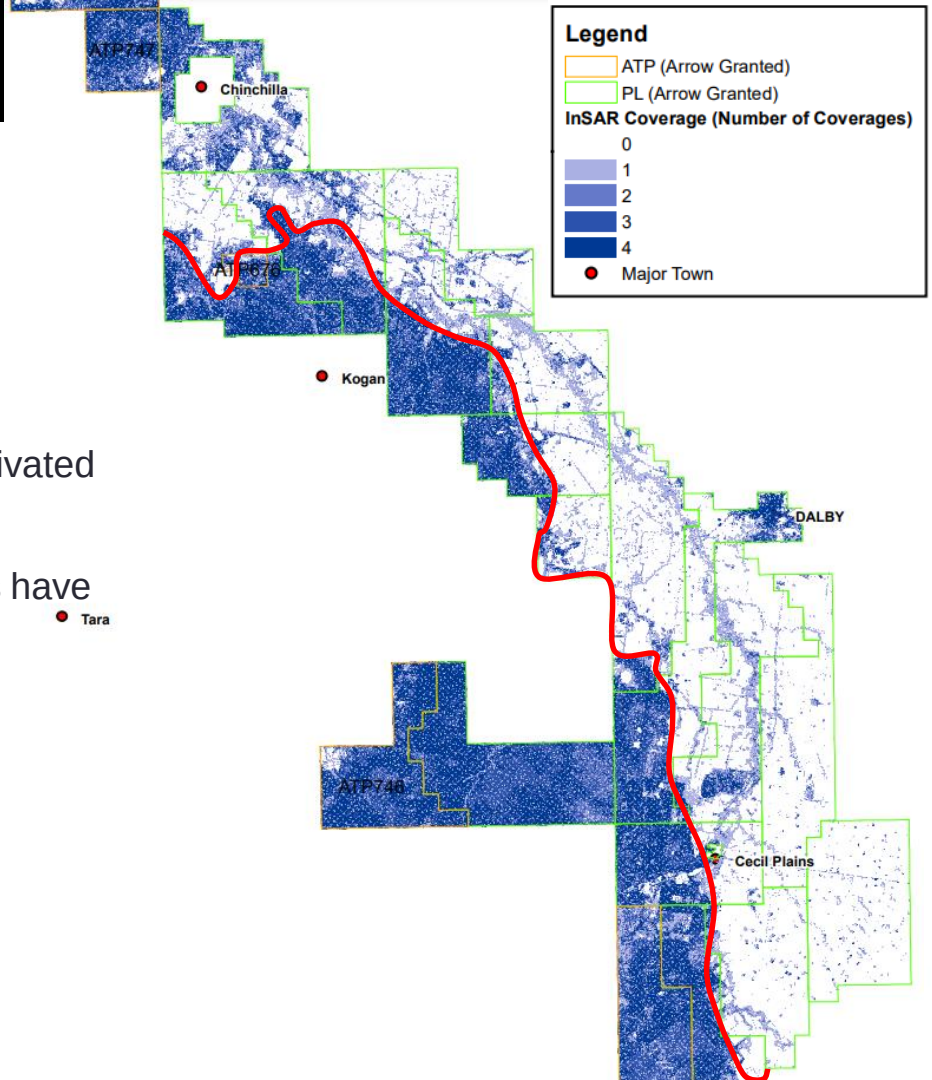

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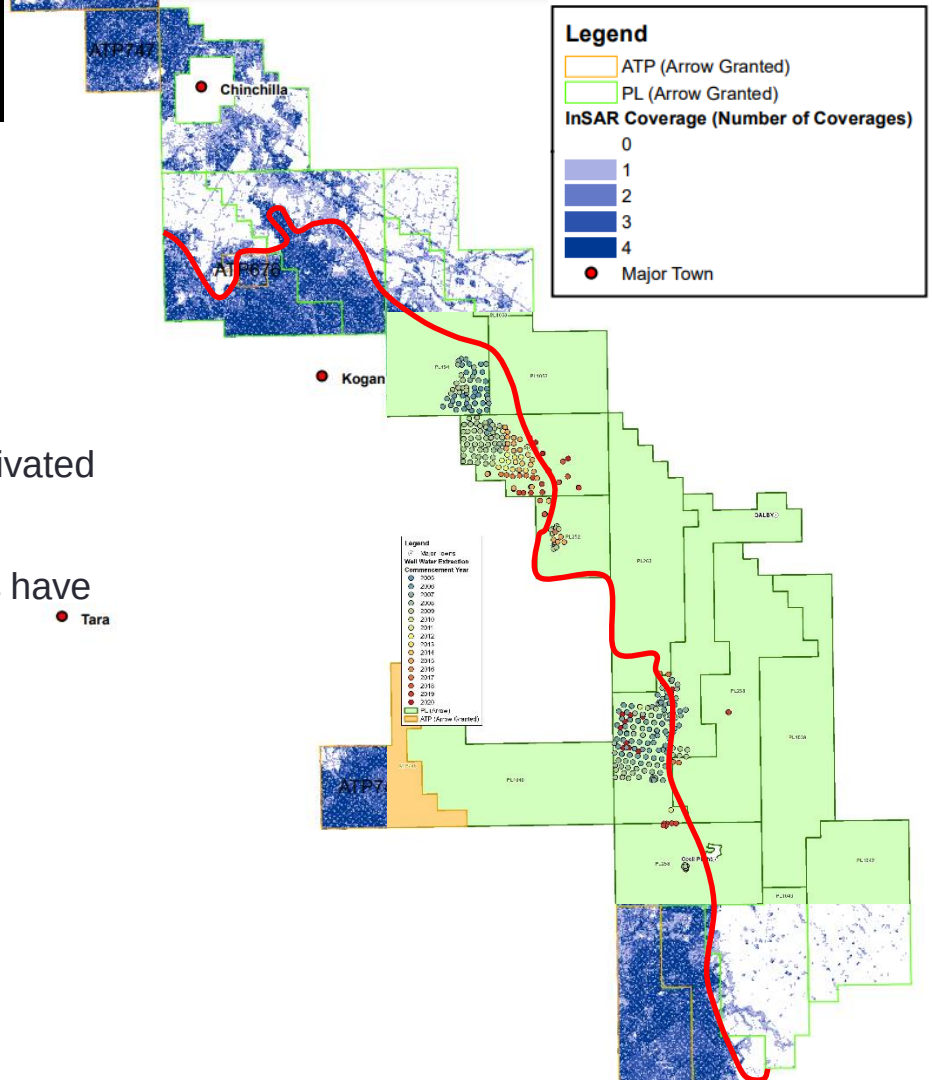

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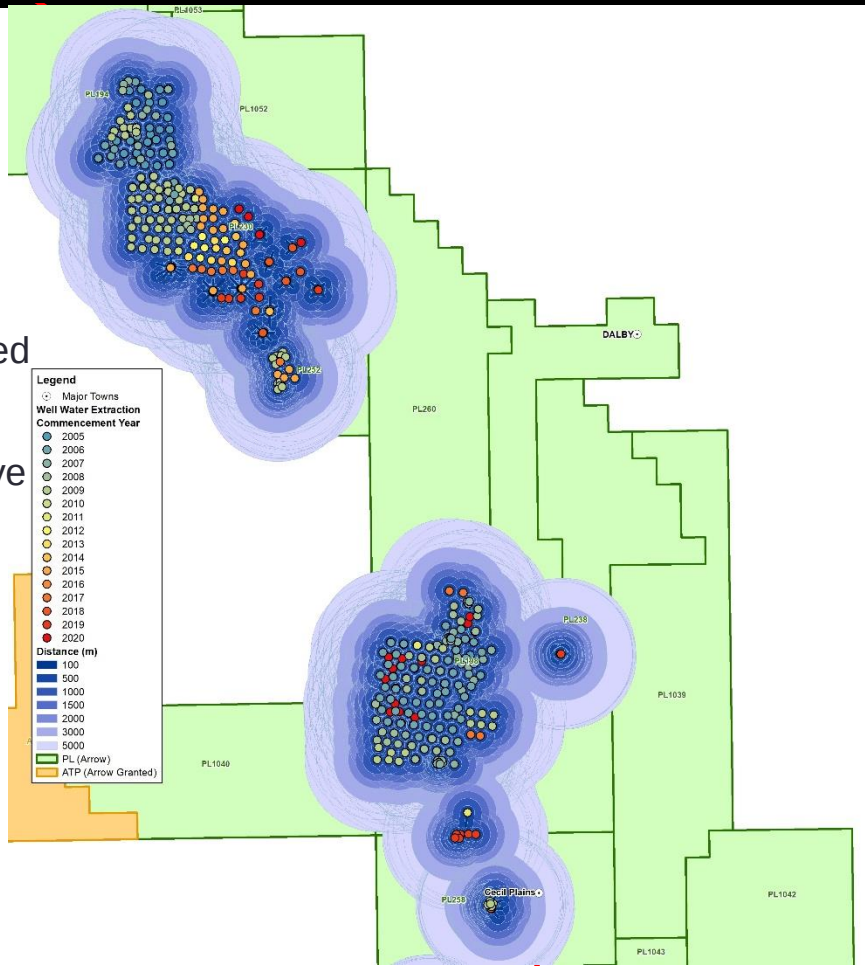

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- Buffer zones created around each CSG well based on distance from wells present in that year
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  - 500-1,000m
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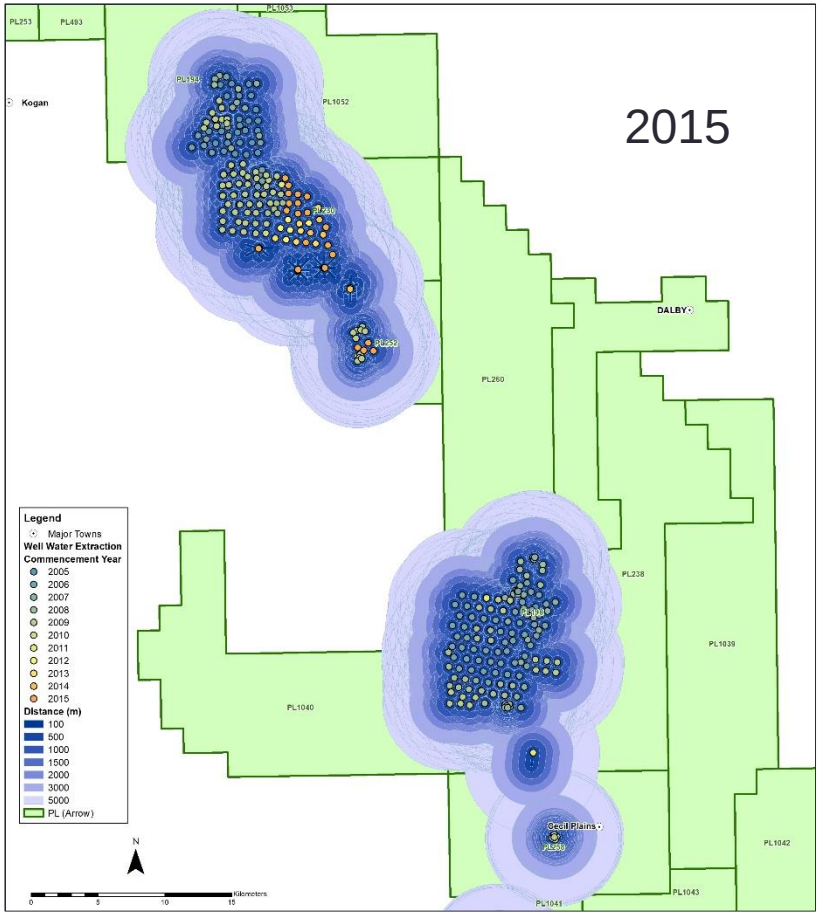
- Ground movement of all InSAR points at same distance averaged.



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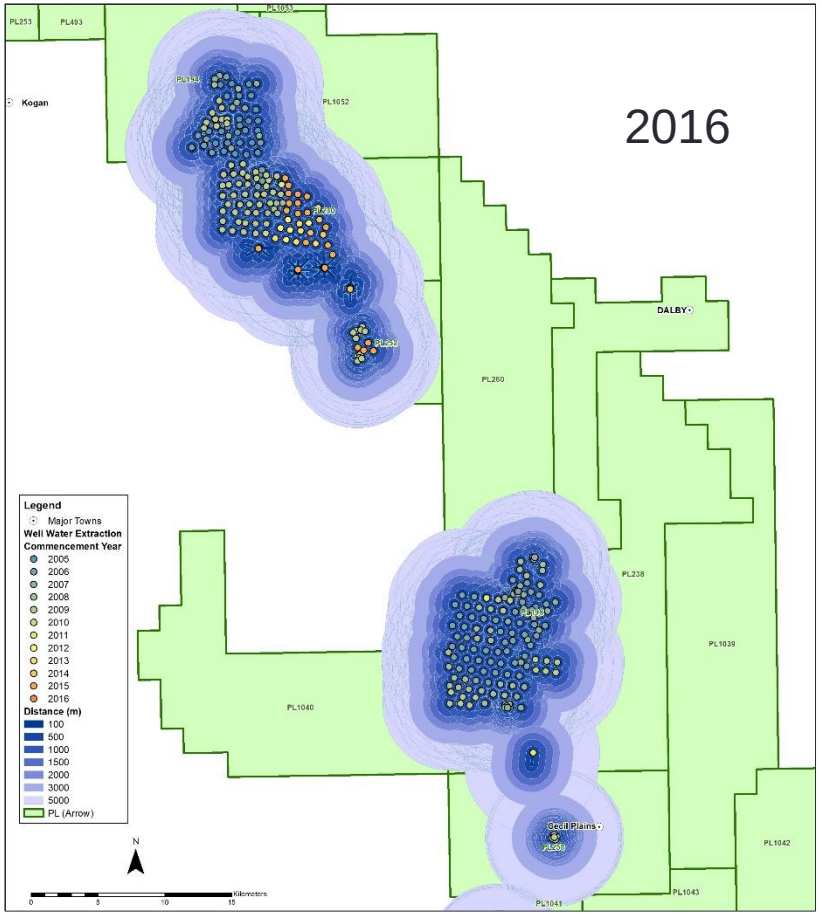

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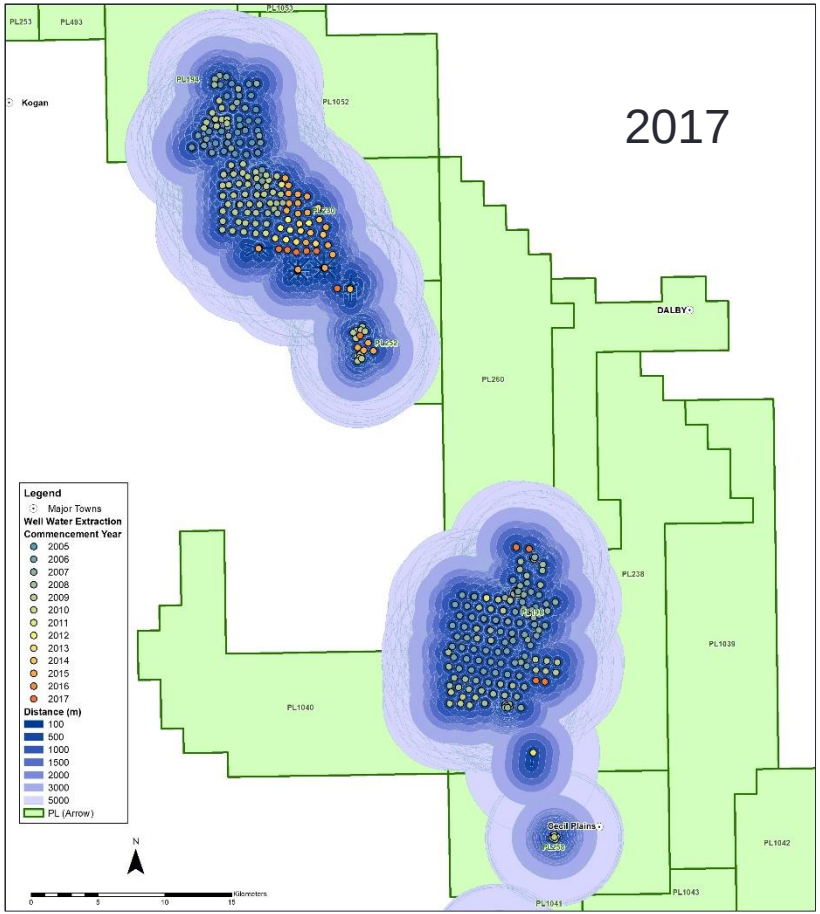

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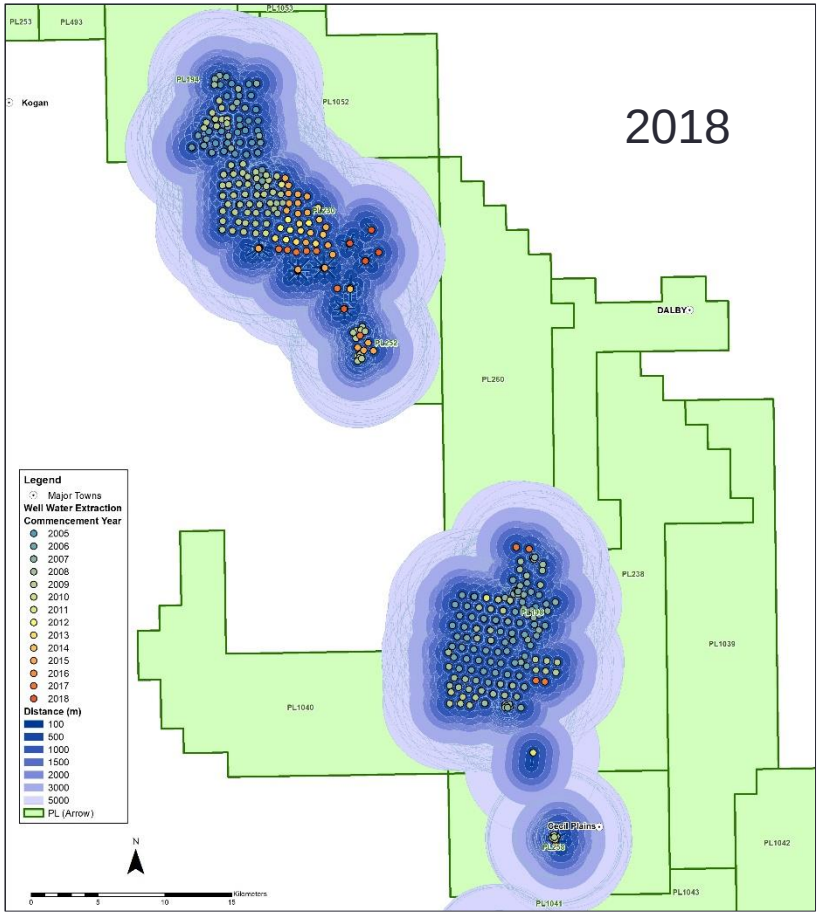

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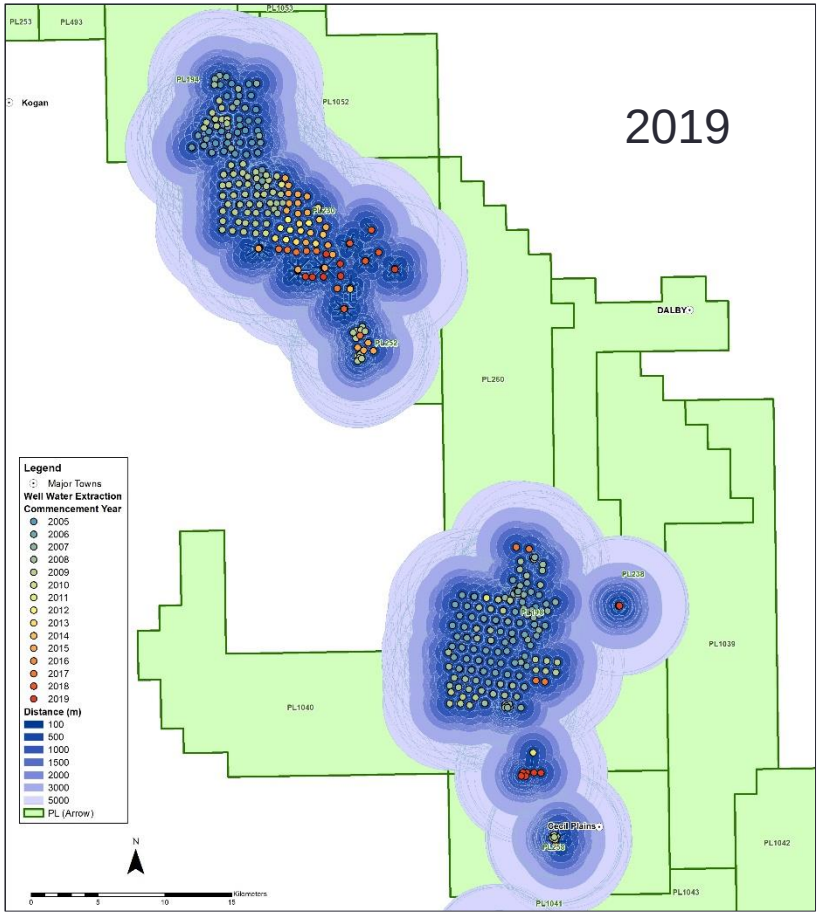

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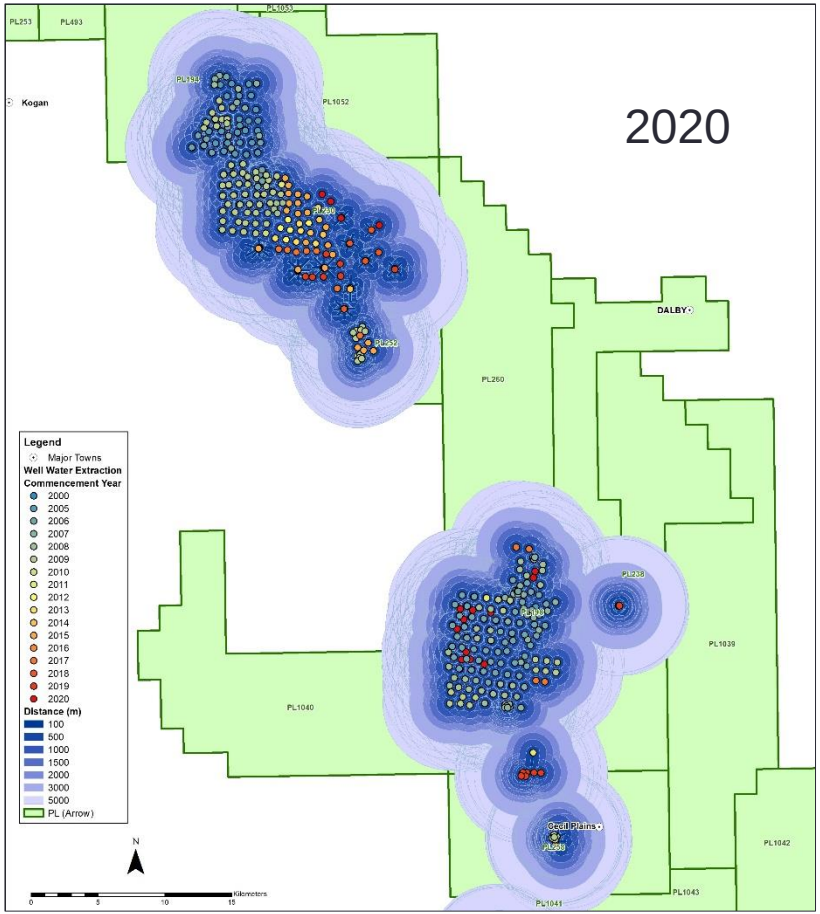
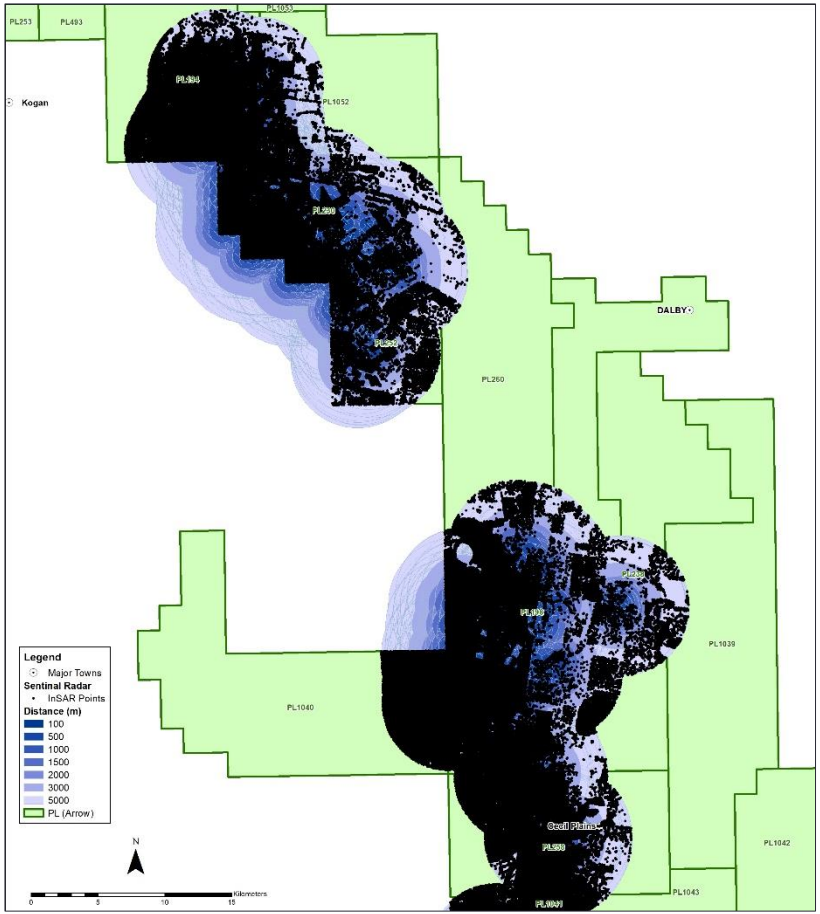


2c Analysis of historical observations; ground movement with distance from wells

- ~160,000 InSAR data points:
  - Acquired by Sentinel satellites,
  - Measured every 12 days,
  - Since August 2015,
  - Used in analysis of historical observations.



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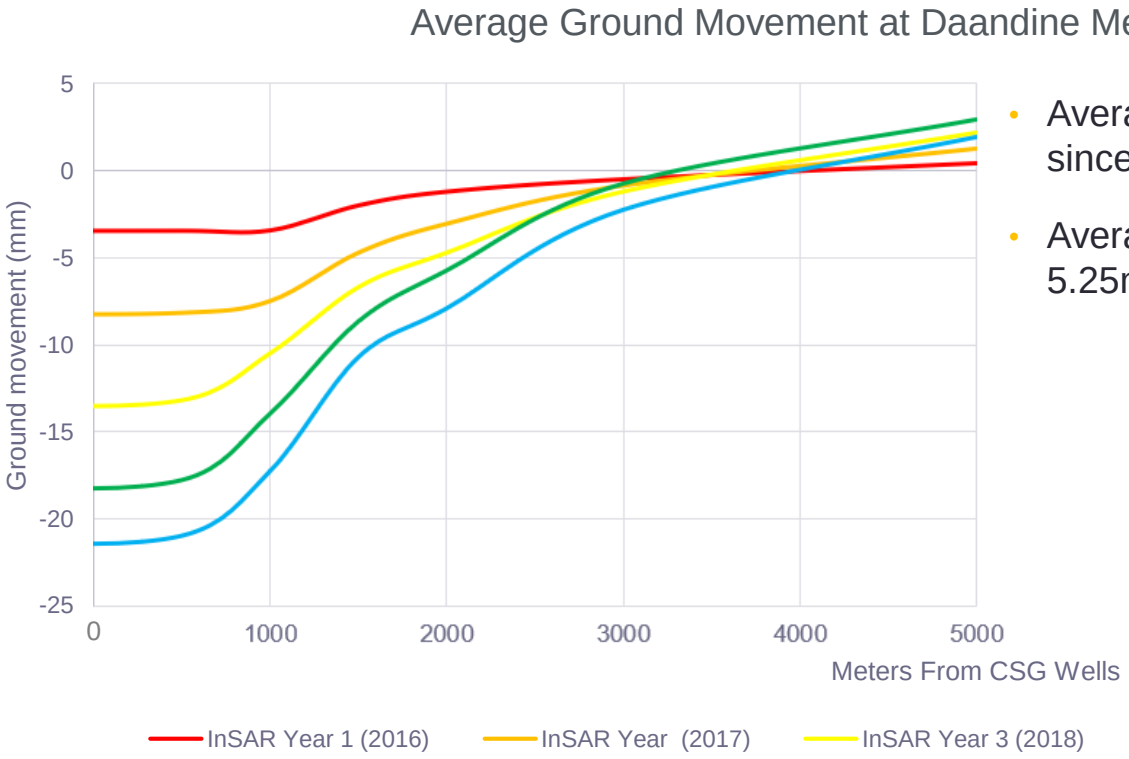
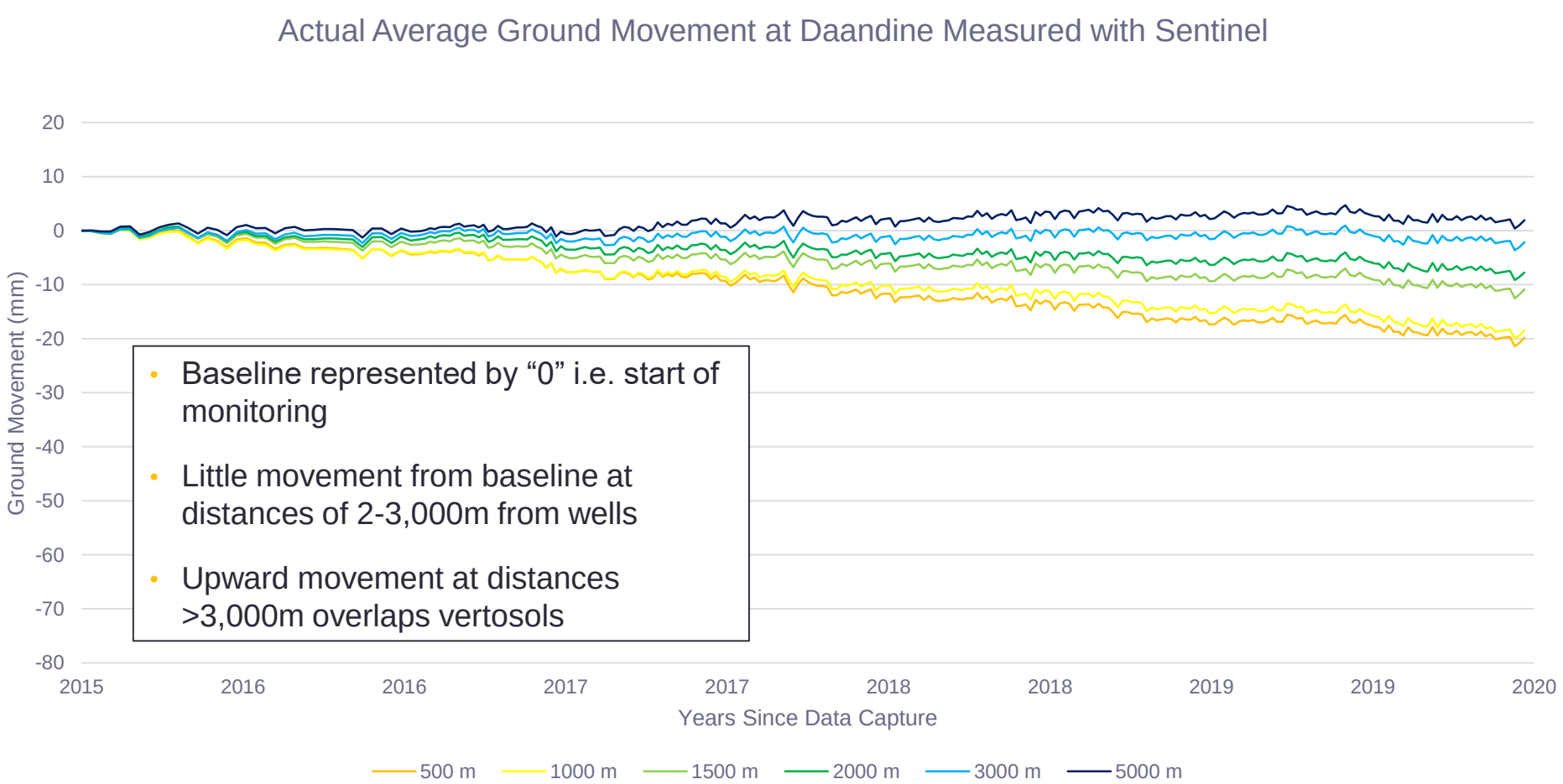


- Average ground movement of ~21mm observed since 2015
- Average gradient change of ~21mm/4km i.e. 5.25mm/km

2c Analysis of historical observations; ground movement with distance from wells



2d Analysis of historical observations; workflow

- Arrow further developed process to evaluate historic ground movement by years since well started production.
- The ‘total’ ground movement presented hereafter has **not** been observed on average.
- InSAR points were classified by:
  - Distance from nearest CSG well, and
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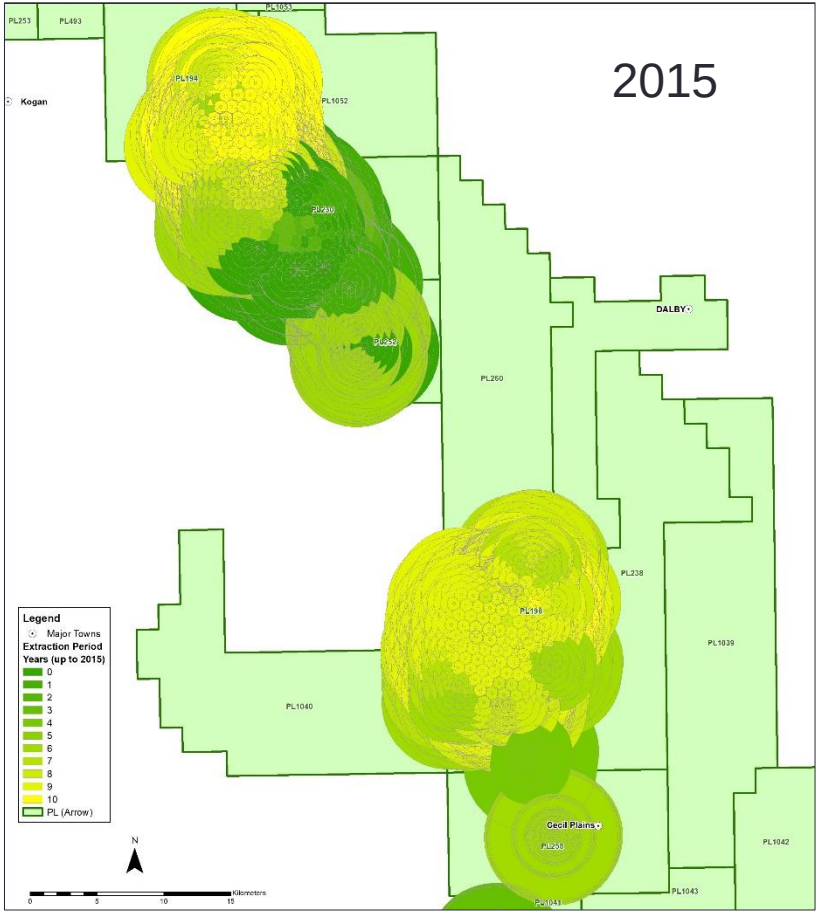
- Processes allowed us to evaluate non-CSG ground movement:
  - Over cultivation
  - Everywhere else



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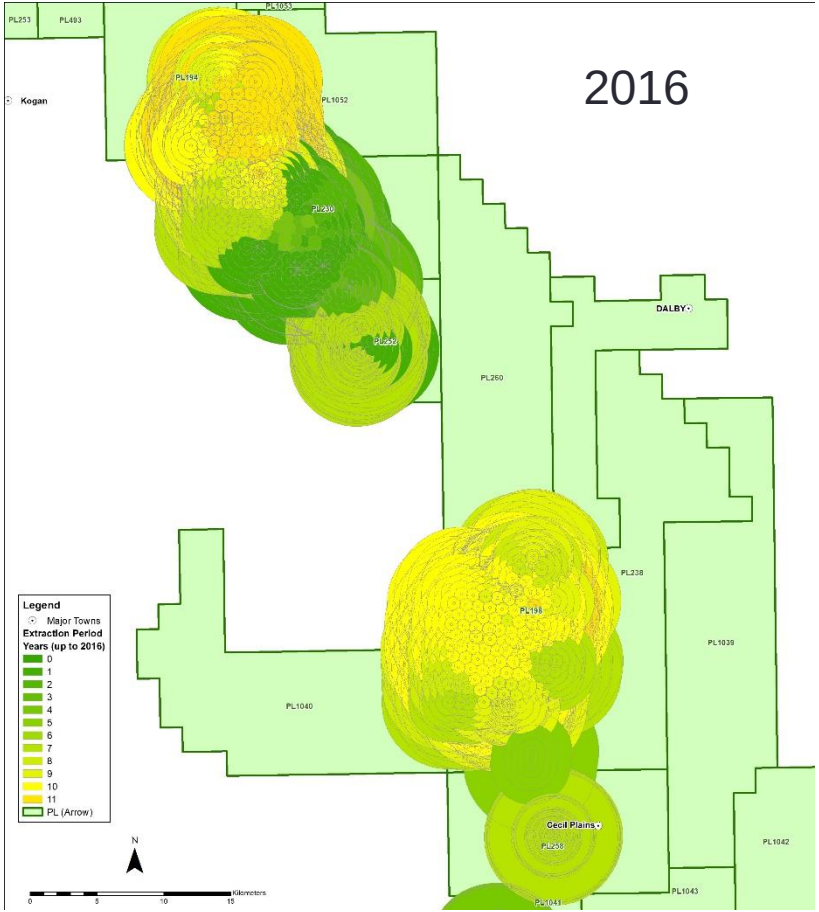

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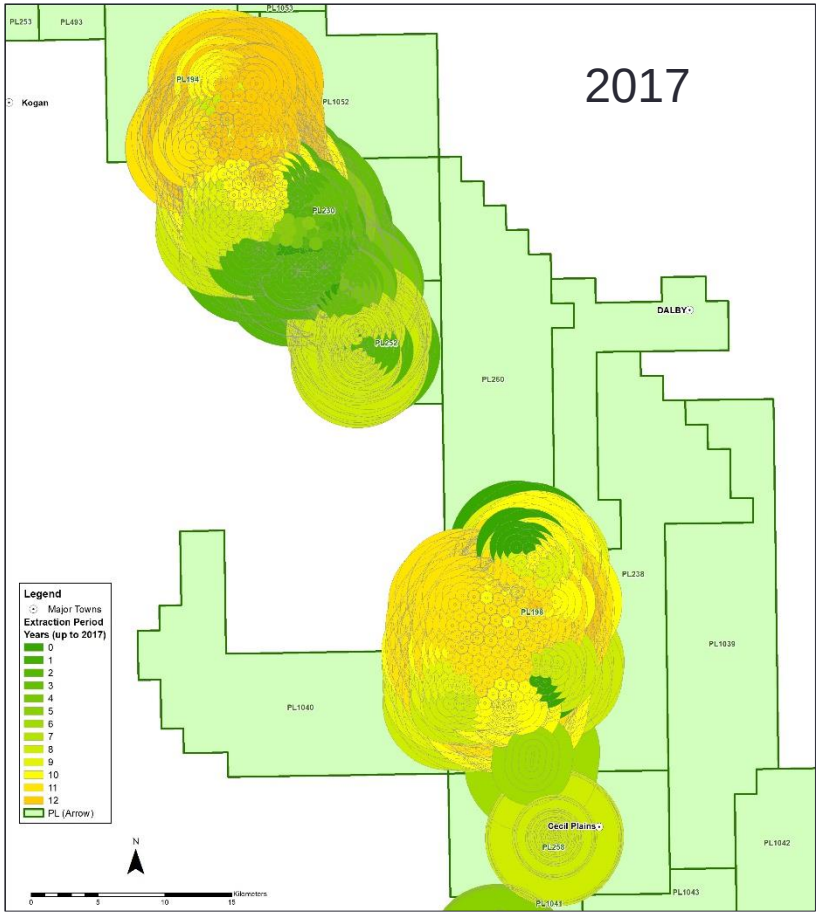

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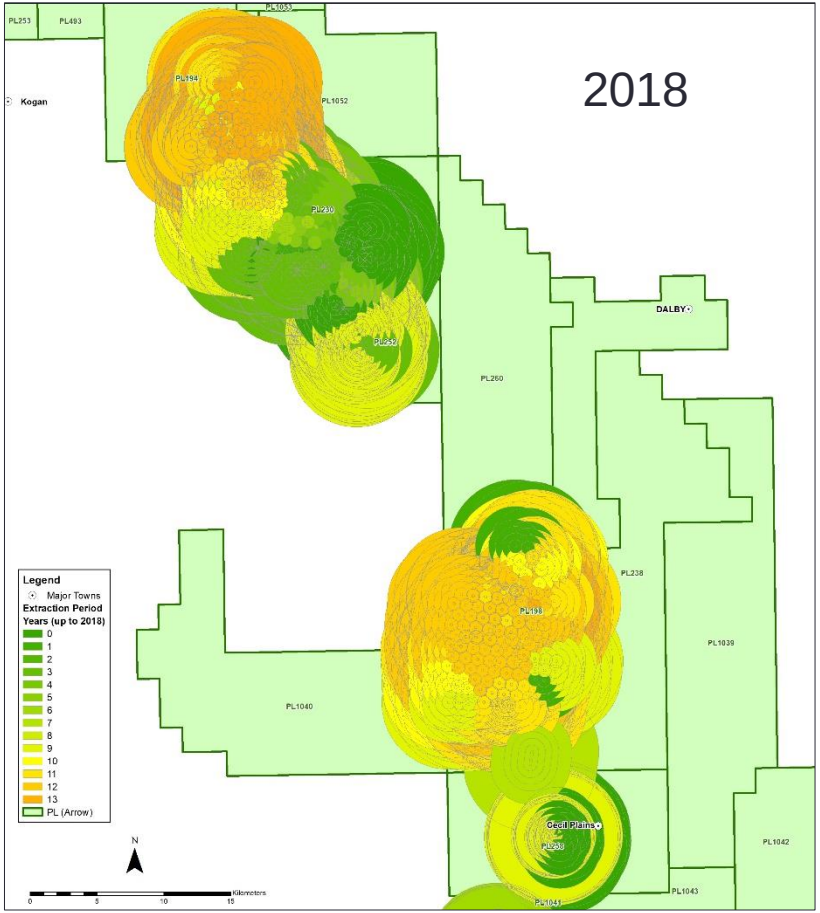

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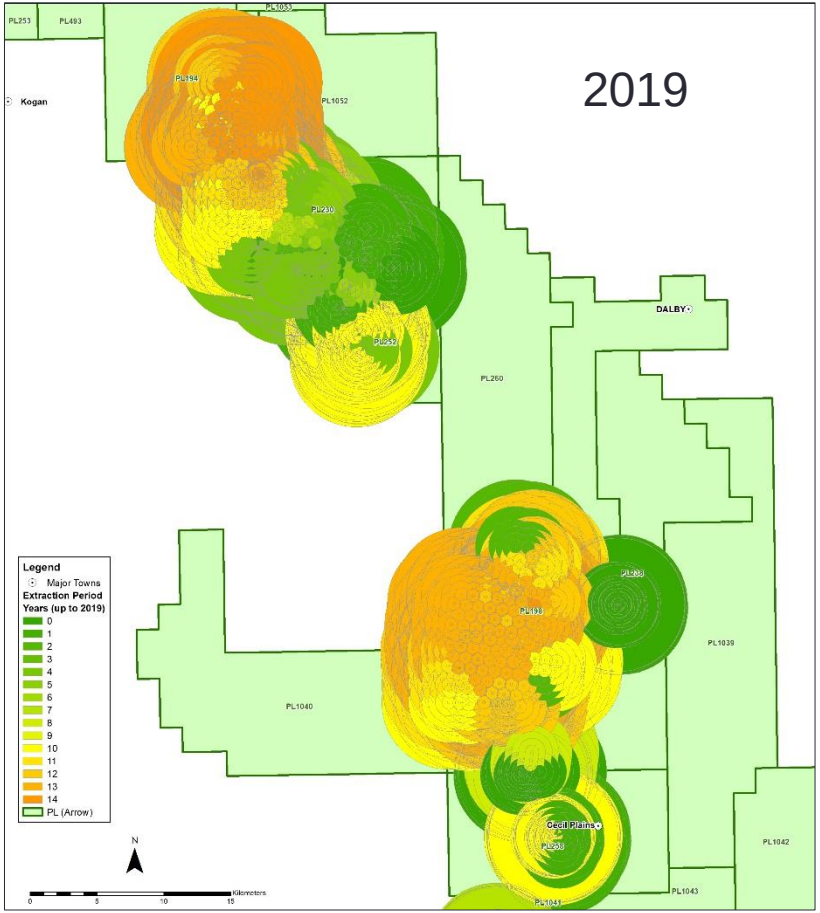

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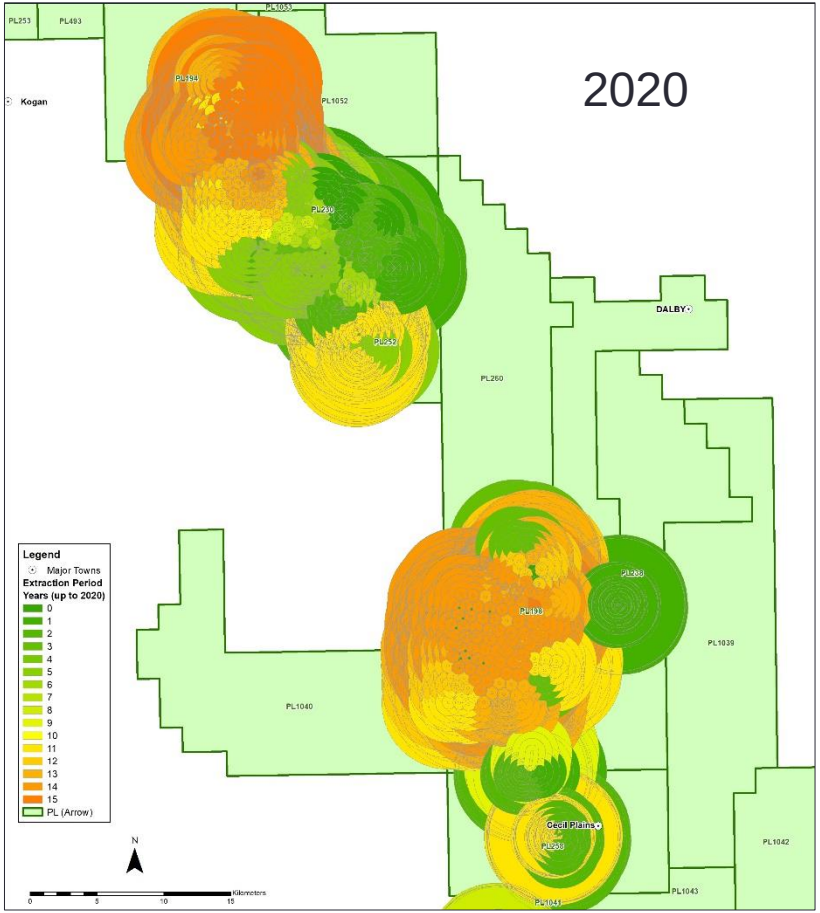

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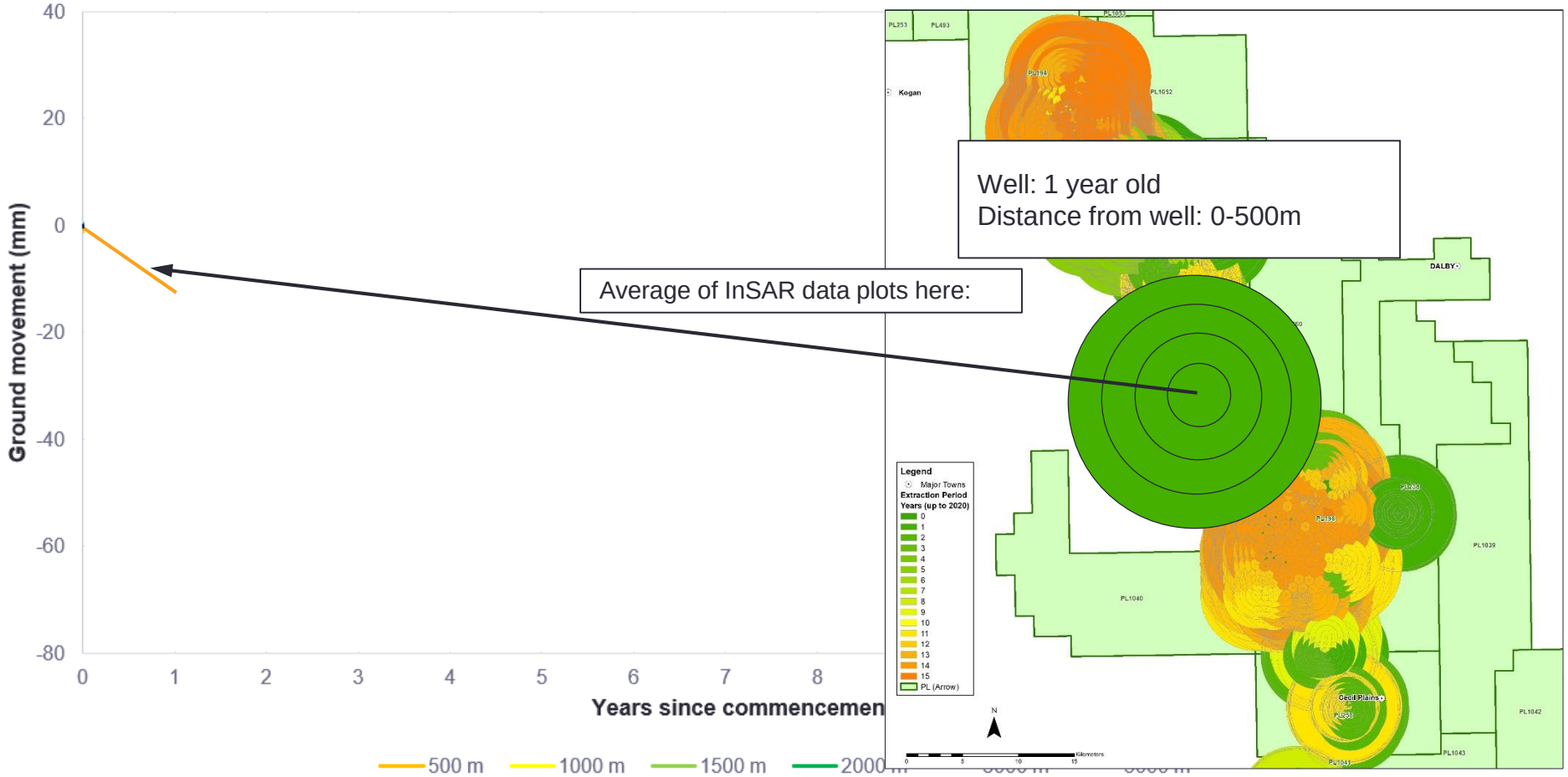

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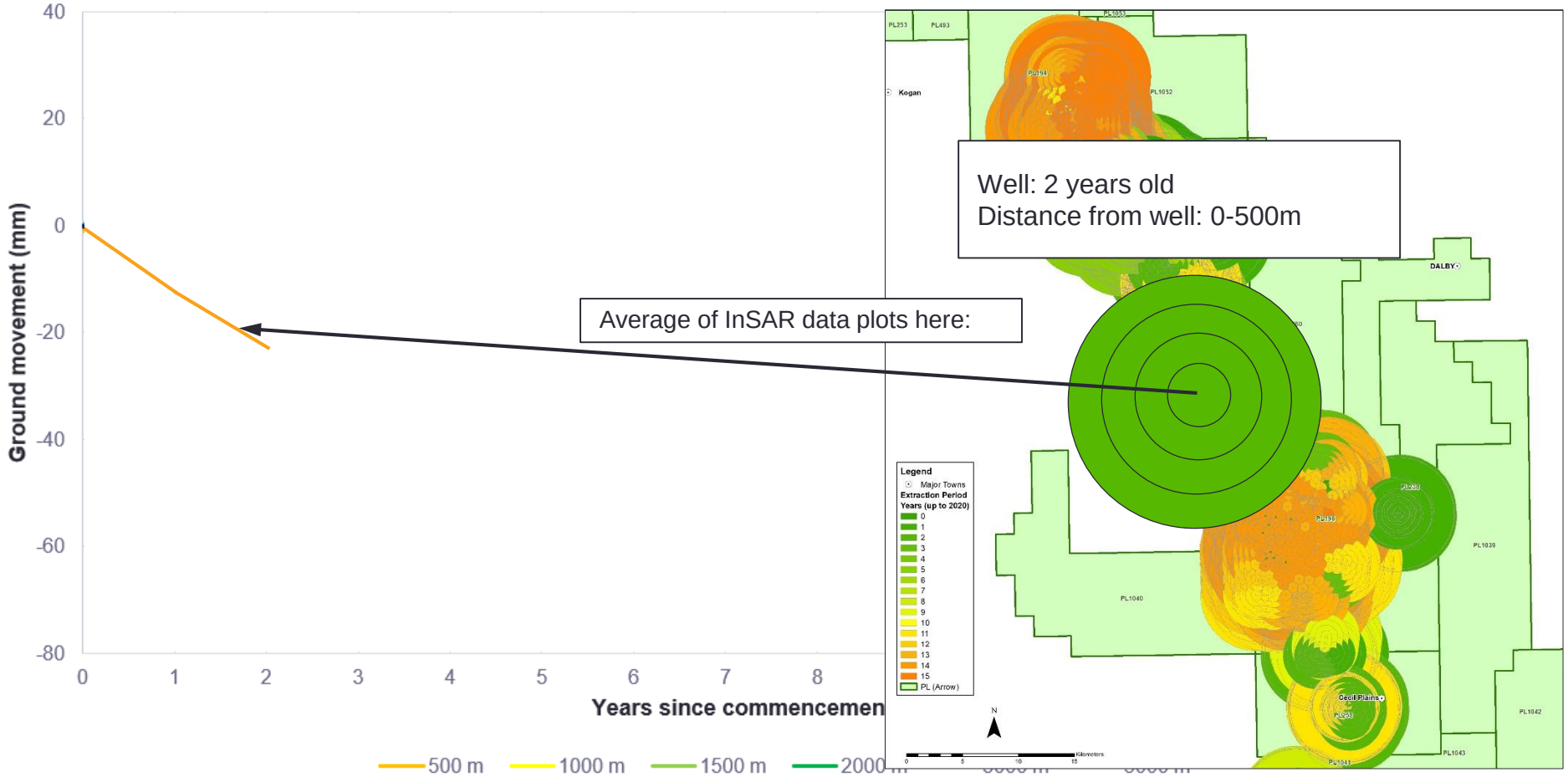

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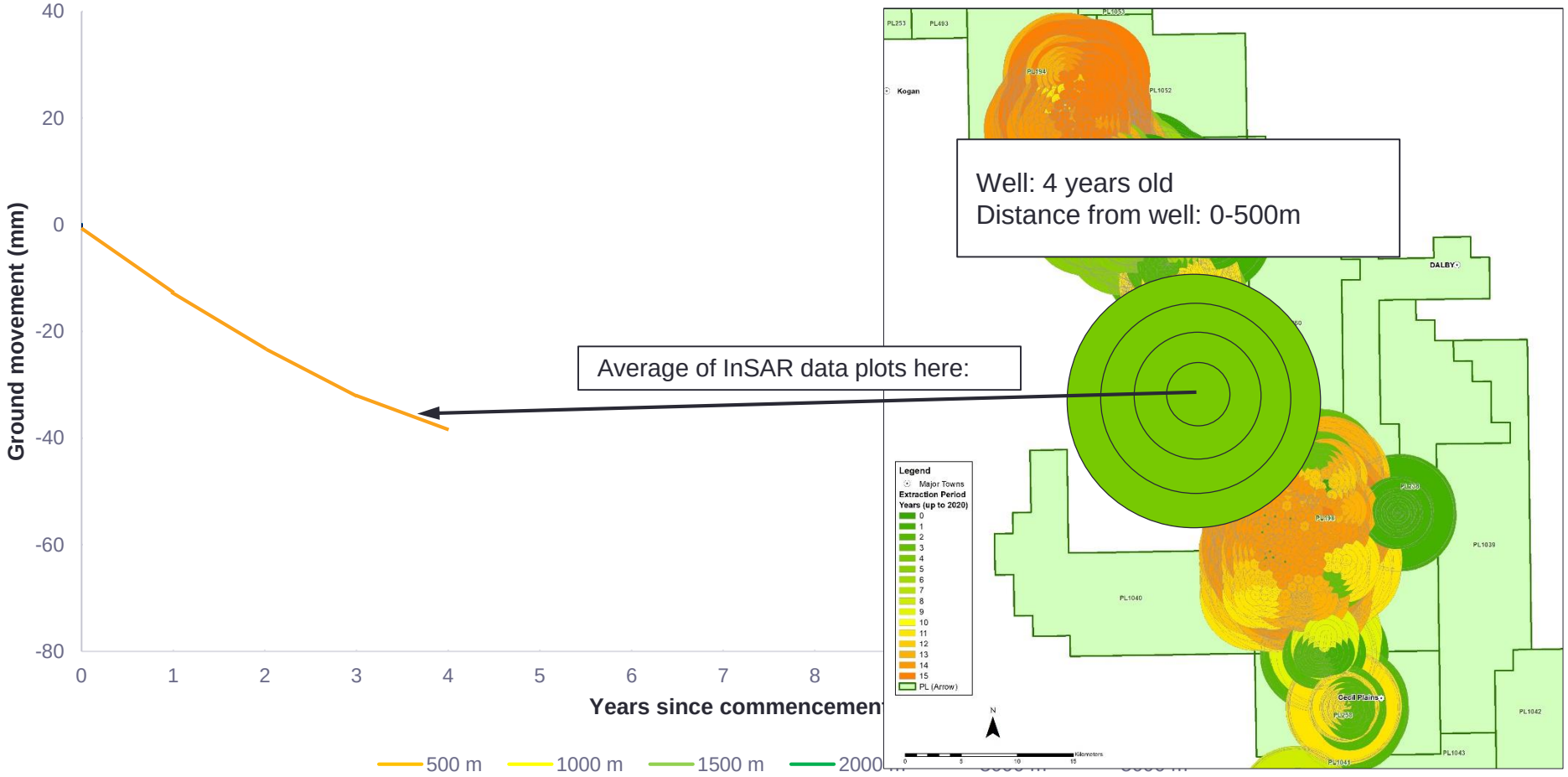

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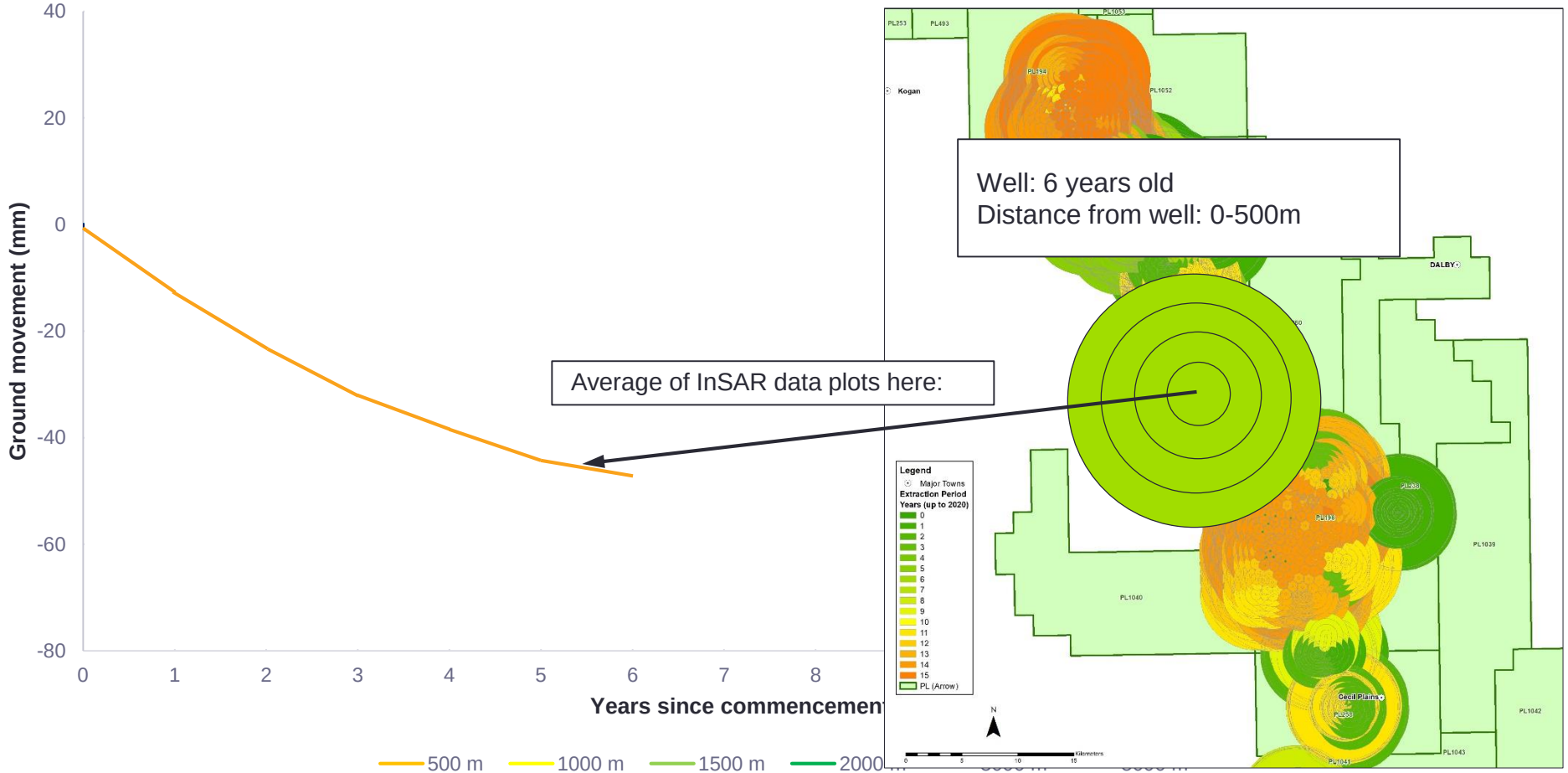

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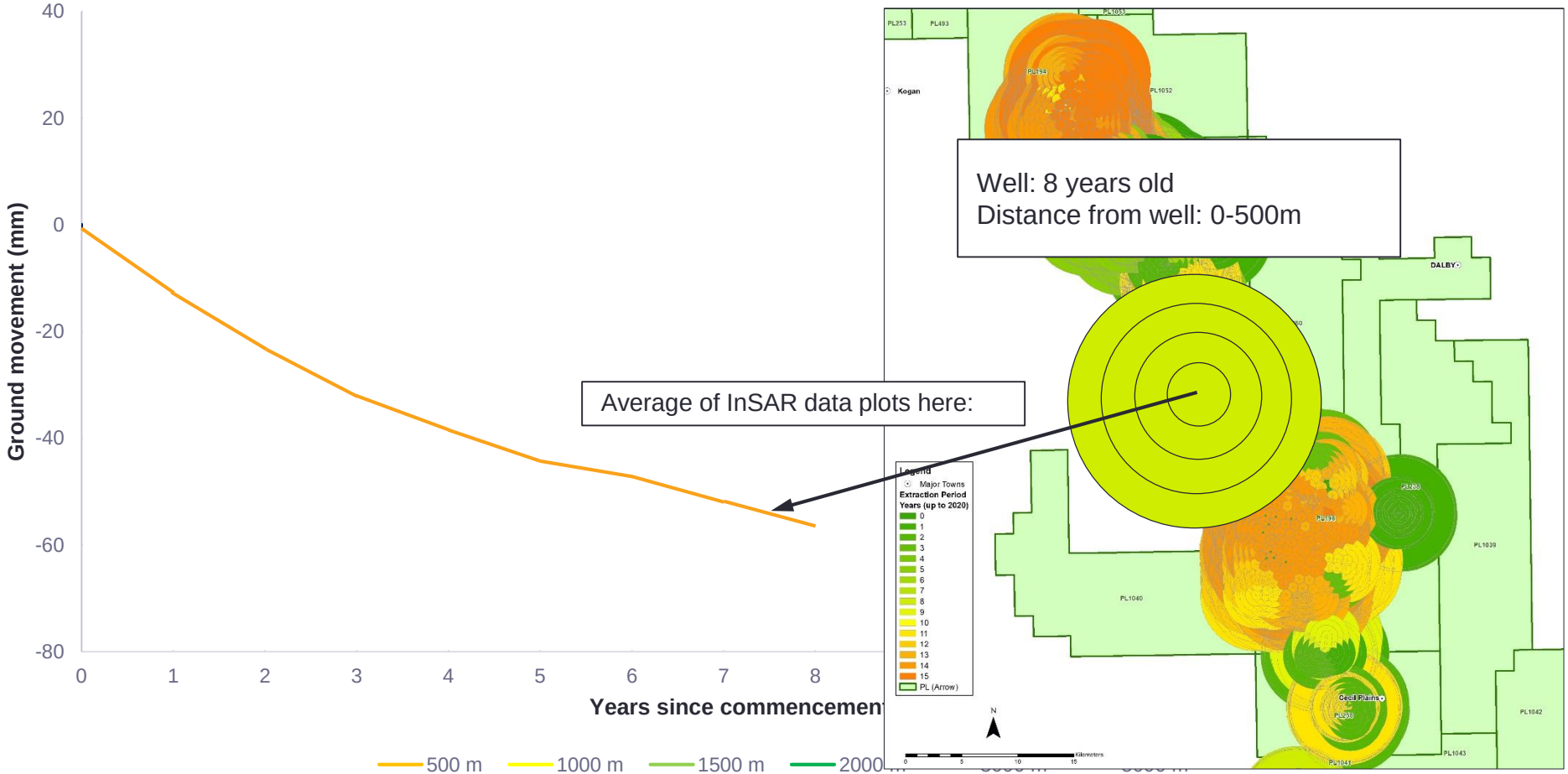

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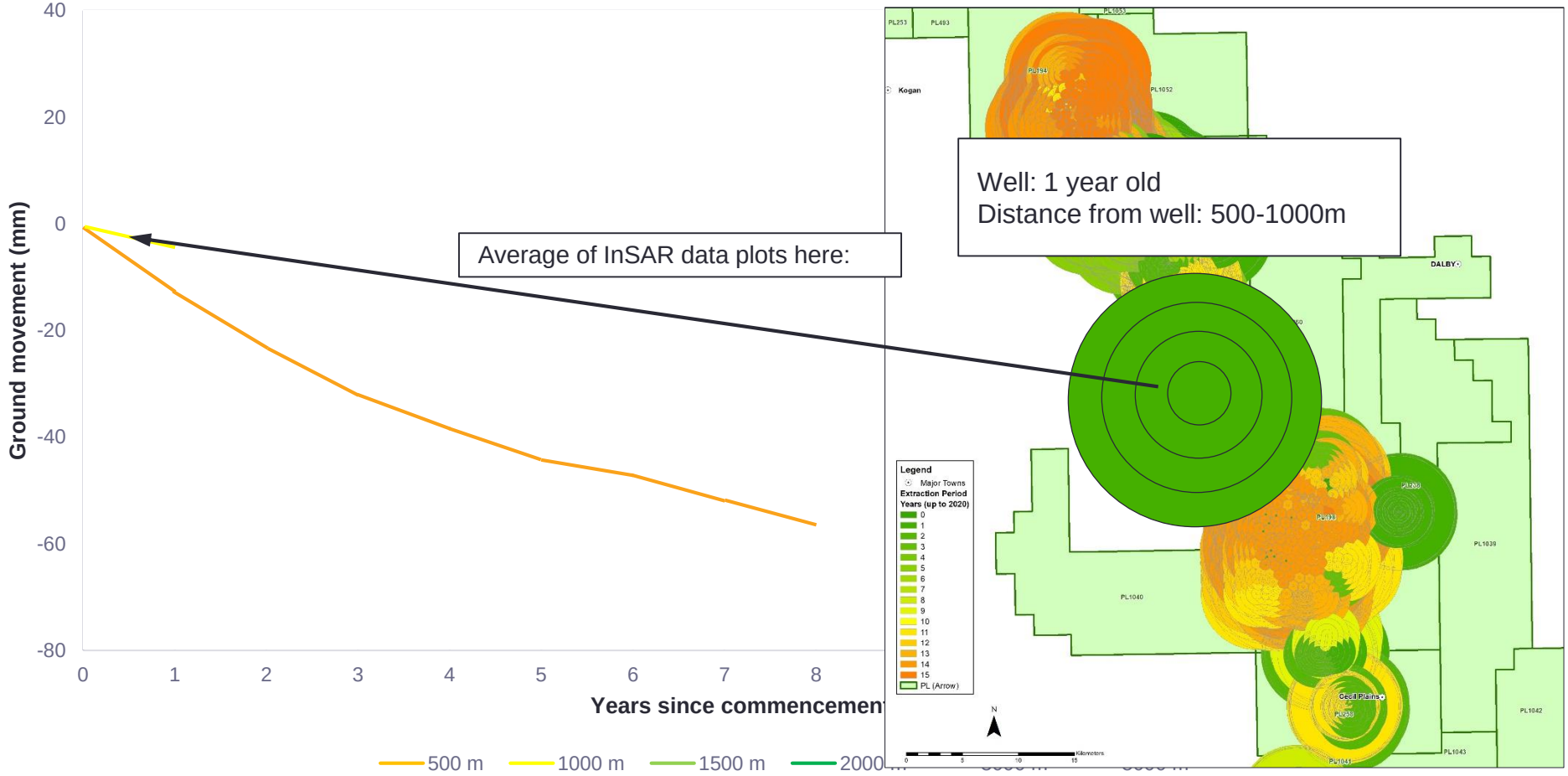

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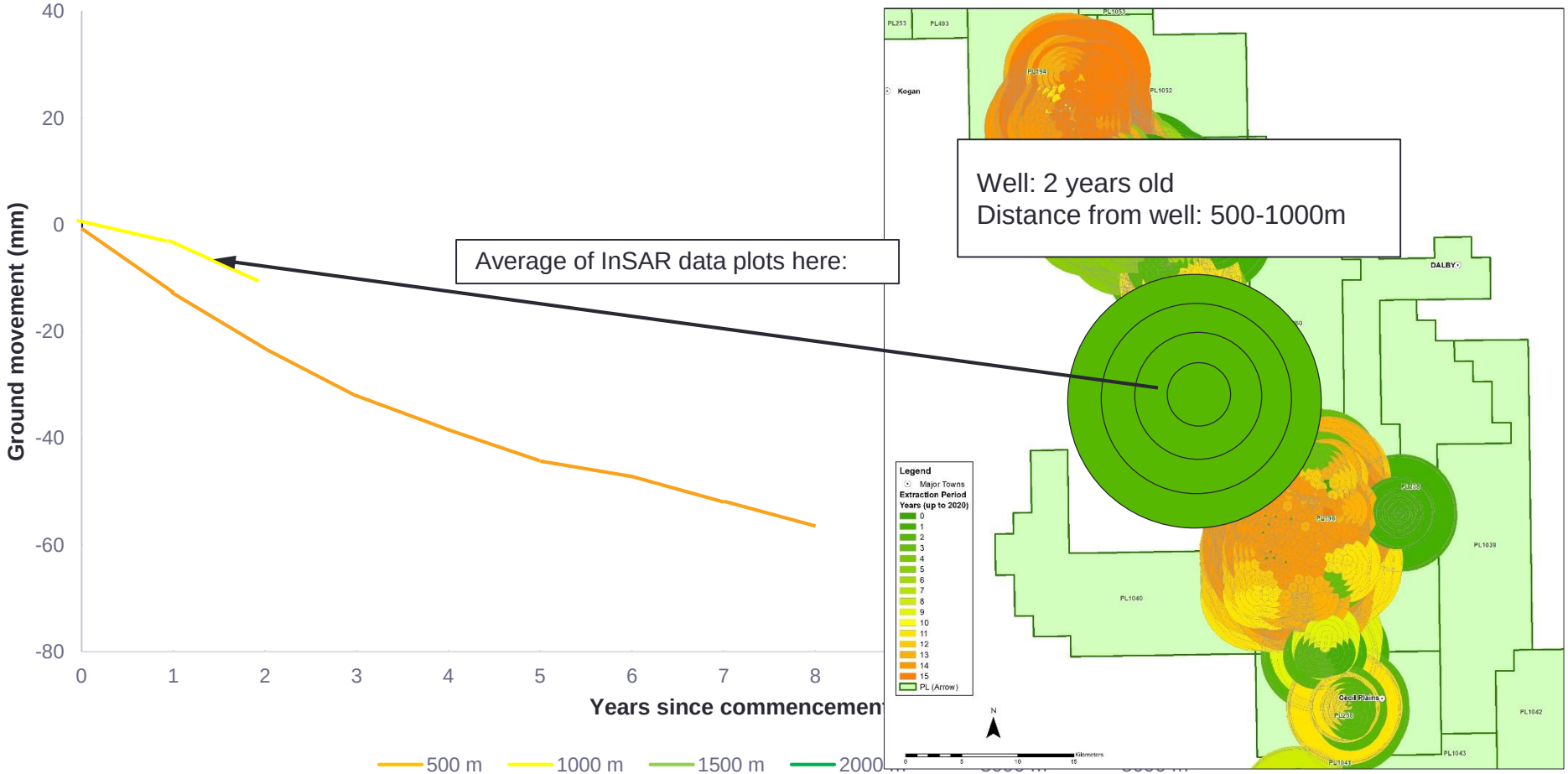

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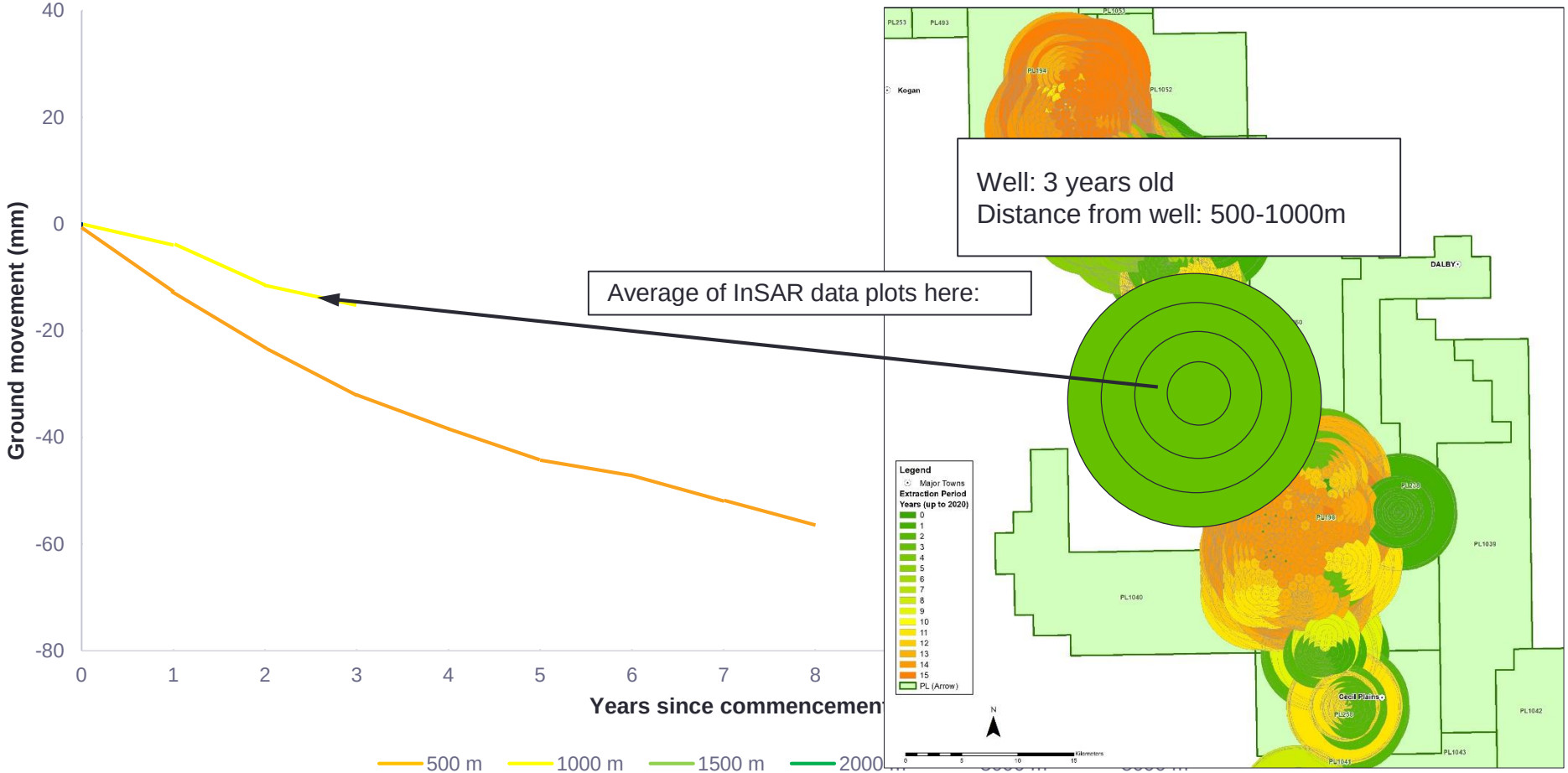

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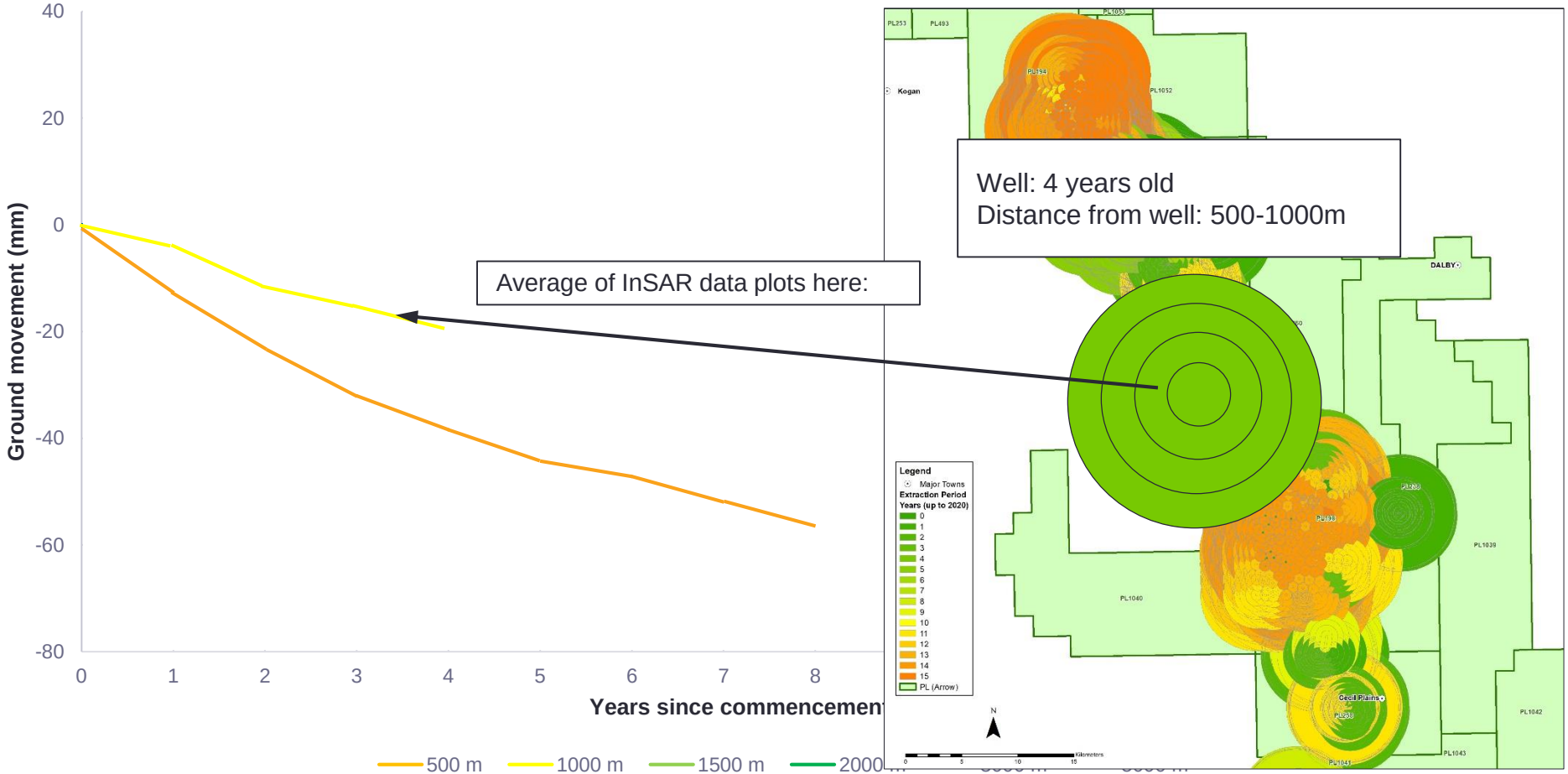

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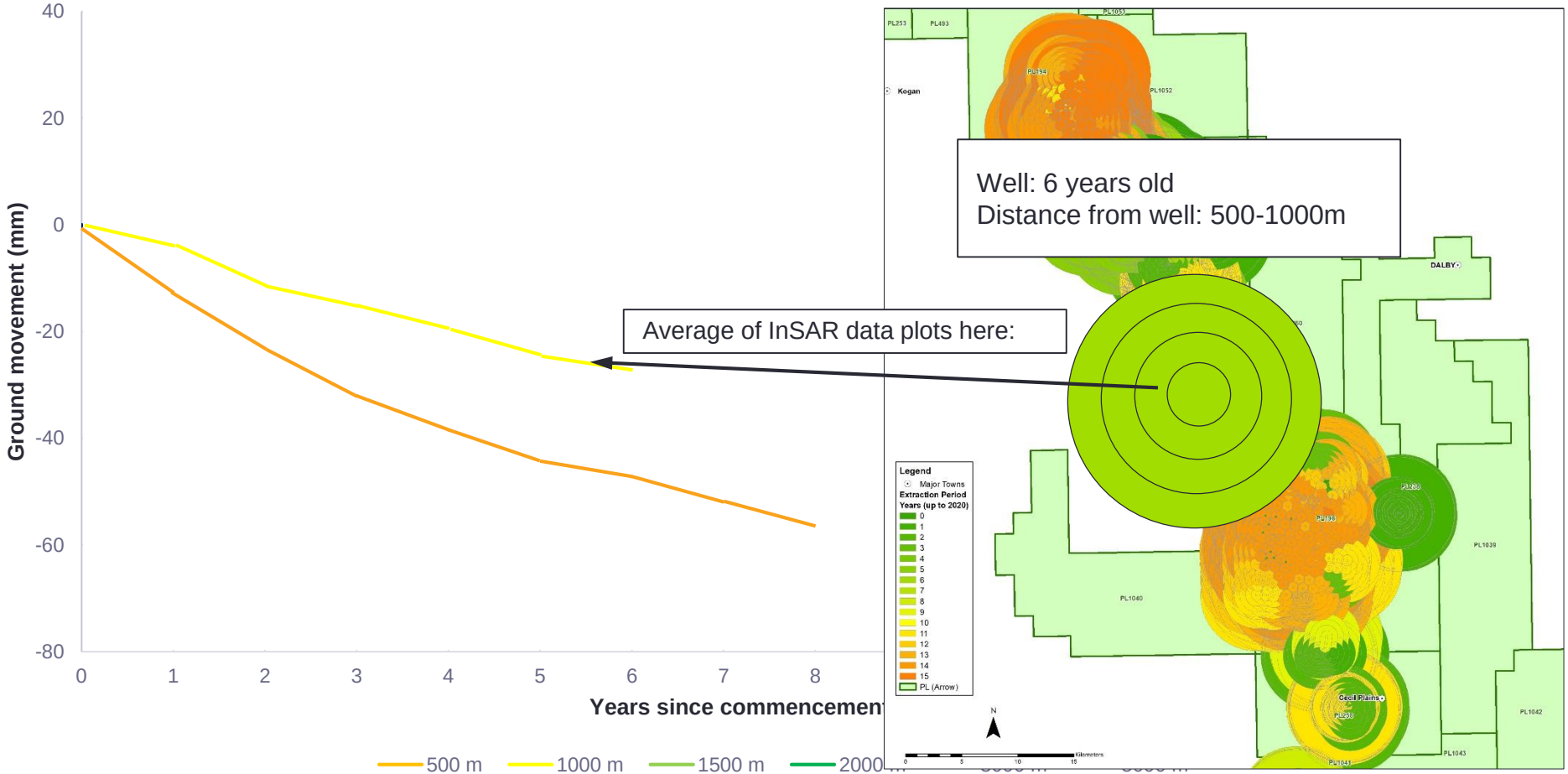

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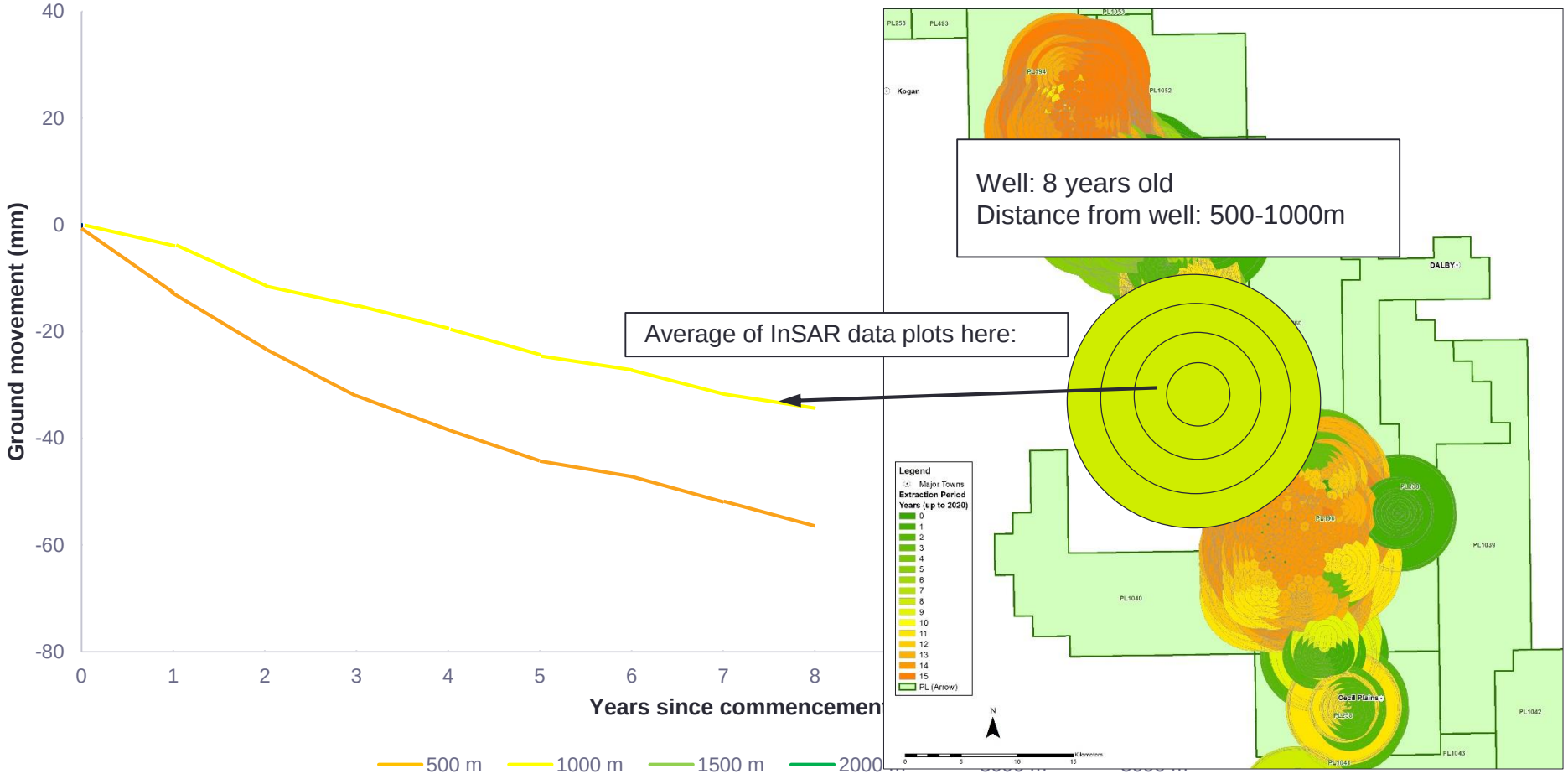
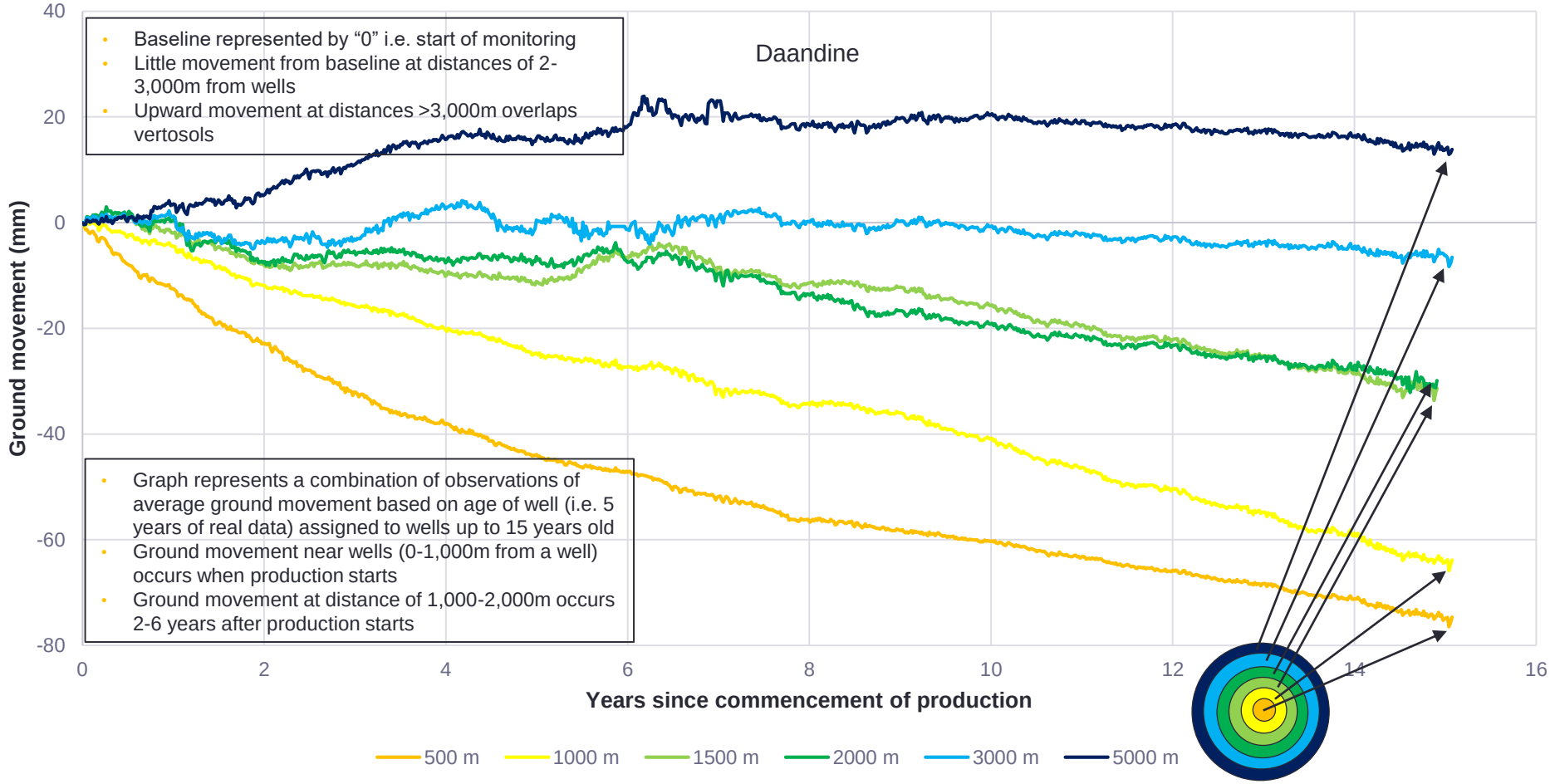


2e Analysis of historical observations; Ground movement with distance and age of wells



2e Analysis of historical observations; Ground movement with distance and age of wells

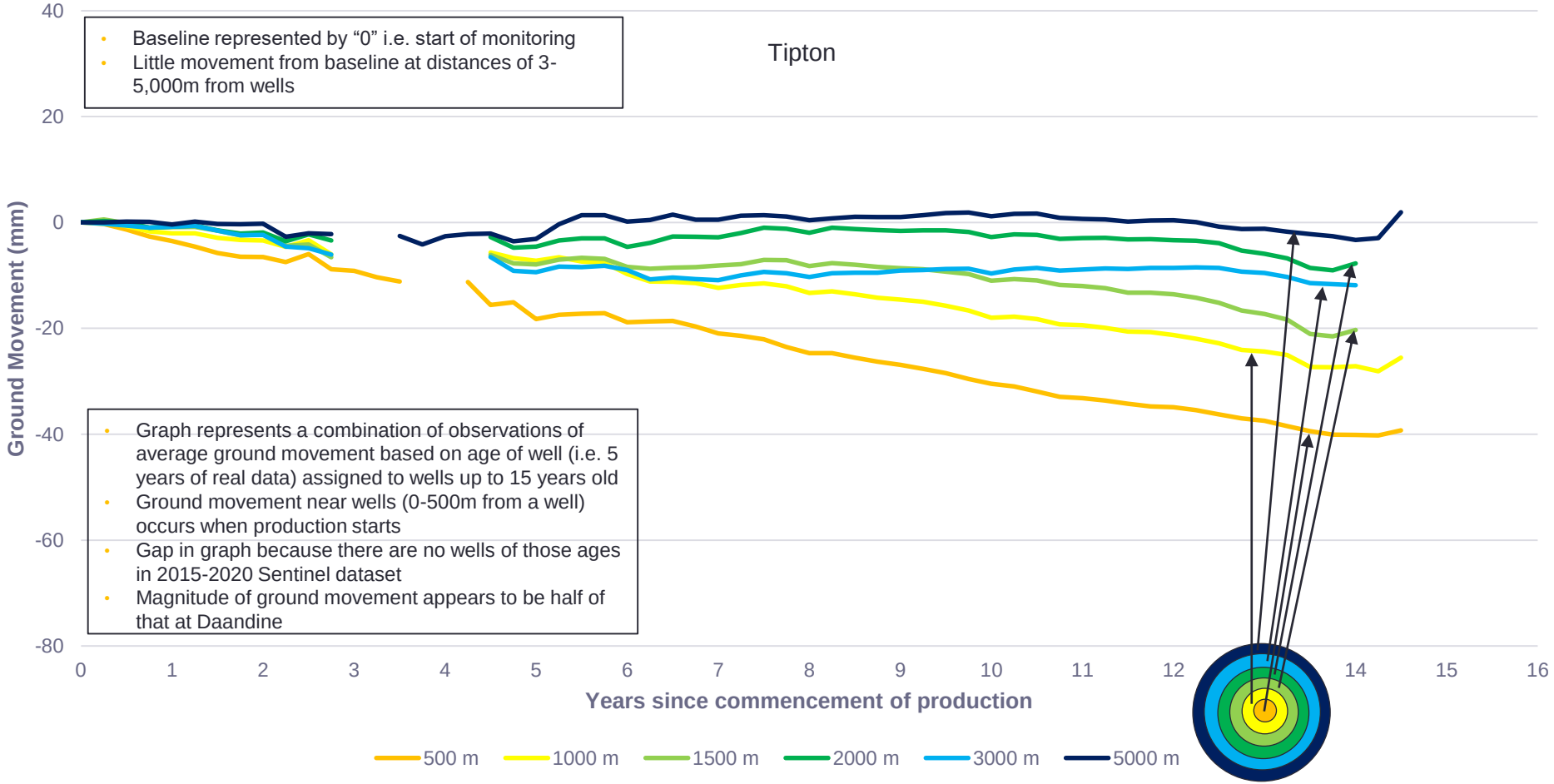
Cumulative Average Ground Movement at Daandine with Distance and Age of Wells

- Graph represents a combination of observations of average ground movement based on age of well (i.e. 5 years of real data) assigned to wells up to 15 years old
- Ground movement of ~75mm estimated in vicinity of wells after 14 years
- Average gradient change of ~75mm/3km i.e. ~25mm/km

2 Relationship between ground movement & age of CSG wells; Tipton

- Baseline represented by “0” i.e. start of monitoring
- Little movement from baseline at distances of 3-5,000m from wells

Tipton



- Graph represents a combination of observations of average ground movement based on age of well (i.e. 5 years of real data) assigned to wells up to 15 years old
- Ground movement near wells (0-500m from a well) occurs when production starts
- Gap in graph because there are no wells of those ages in 2015-2020 Sentinel dataset
- Magnitude of ground movement appears to be half of that at Daandine

2 Analysis of historical observations; peer review

- We have shared our data and workflow with OGIA who are intending to review the methodology and build further on the analysis.
- This may include:
  - Provision and explanation of the procedure to OGIA
  - Assessment of the procedure by OGIA
  - Verification of the results of Arrow's analysis
  - Review of the statistical significance of the results including correlation with CSG activities.
- This process has commenced.

2 Analysis of historical observations; summary

- Presented our workflow and some findings of the analysis of historical data (LiDAR and InSAR observations) undertaken which indicates:
  - Greater than 92% of slopes in Arrow's tenure are steeper than 600mm/km
  - Actual observed ground movement (using Sentinel) at Daandine was (on average) ~20mm
  - Average gradient changes between ~5mm/km and ~25mm/km; consistent with previously presented modelling indicating a minor impact
  - Ground movement commences upon operation of wells
  - Highest magnitude occurred near CSG wells (i.e. within 1km)
- We will present additional analysis following OGIA's review e.g.:
  - Ground movement greater than 5km from CSG wells, and
  - Ground movement on different soil types.

Ongoing and completed works

3 Completed and ongoing works

Committed work (from July 2020)	Status
Increase data collection to further understand historical data and inform modelling	Peer review
Update subsidence model with observations since 2015	Draft report received
Consider including interim-findings of UQ research into updated model including natural (non-CSG) processes which affect ground movement.	In progress
Continue to work with InSAR provider to improve data presentation e.g. by evaluating possibility of capturing images at particular times in cropping cycle	Reprocessing complete
Work with precision agriculture entities to better understand non-CSG related ground movement across cropping land including: • accuracy of measurement and levelling techniques, and • this will inform Arrow's modelling, monitoring and evaluation of remediation options	Complete
Installation of ground movement monitoring stations at 4 locations across tenure	¾ installed
Acquire updated LiDAR (3rd collection) across cropped land on Arrow tenure	Complete
Submit revised Updated WMMP	Complete

Summary

Summary

- Analysis of historical observations indicates CSG-induced subsidence is unlikely to be perceptible at property scale and small compared to natural variability (such as from rainfall)
- Arrow's monitoring process, which is consistent with industry standard, utilises:
  - InSAR to identify regional ground movement at a screening level, and
  - Other survey techniques (such as LiDAR) to identify changes in slope
- An amended WMMP has been submitted to provide clarity, including a process for considering impact.
- We have developed a workflow which allows us to analyse InSAR data and evaluate ground movement with respect to relevant factors.
- OGIA are reviewing this methodology.
- We have installed 3 out of 4 ground-truthing monitoring points.
- We will continue to update our subsidence model and identify other improvements to the management of subsidence as necessary.




Safety moment | Field development plan | Questions raised | Deviated wells | Break | Subsidence | **Q&A** | Next steps



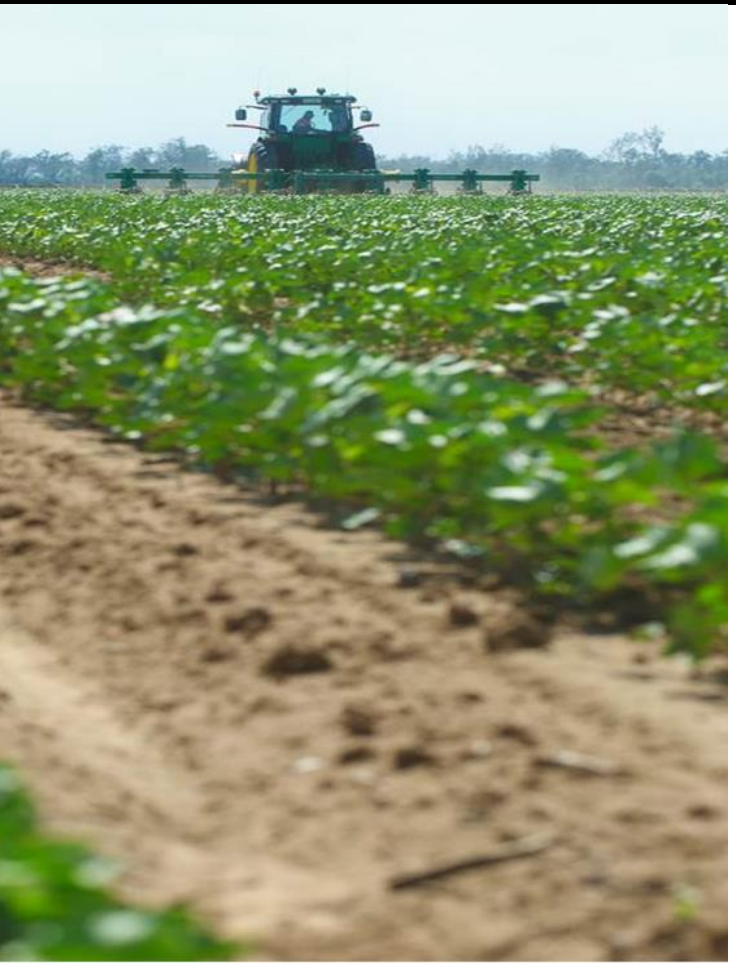

Q&A




Safety moment | Field development plan | Questions raised | Deviated wells | Break | Subsidence | Q&A | **Next steps**

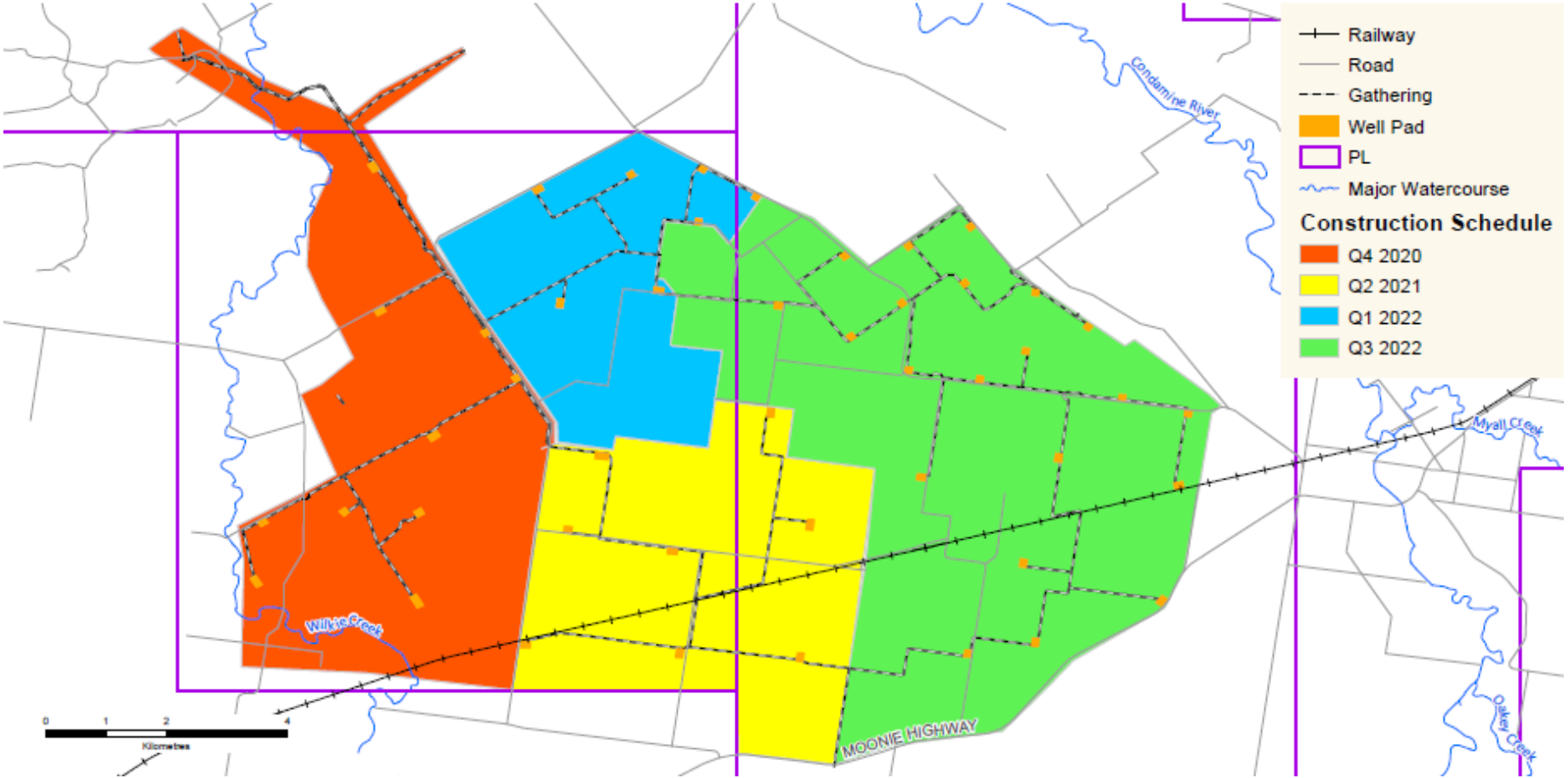



Recap: why are we here today



- Our objectives were to:
  - present the field development plan
  - demonstrate the actions we are taking to address your concerns
  - provide an update on our deviated wells approach, and subsidence monitoring activities
  - explain next steps and timeframes

Next steps


Railway
Road
Gathering
Well Pad
PL
Major Watercourse
Construction Schedule
Q4 2020
Q2 2021
Q1 2022
Q3 2022
Condamine River
Myall Creek
Oakey Creek
Wilkie Creek
MOONIE HIGHWAY
0
1
2
4
Kilometres


arrow energy
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