4. Evaluation of resource interactions

As described in the methodology section, the evaluation of resource interaction potential was performed on the basin-scale by investigating the distribution of each subsurface resource in the form of suitability maps, the overlap of resources in a certain geological interval (interaction maps), potential interactions of specific resources (thematic interaction maps) and the cumulative overlap of resources throughout the sedimentary column (cumulative interaction map and integrated cumulative interaction maps) (Figure 19). A more detailed assessment was performed for Dongara, Beharra Springs and Donkey Creek Terraces.

4.1. Basin-scale results

4.1.1. Suitability maps

The suitability maps (Figure 19) provide a foundational assessment of subsurface resource potential across multiple stratigraphic intervals in the northern Perth Basin. The maps define areas where petroleum, CGS, geothermal, UGS, and groundwater resources are most favourable based on geological, structural, and technical factors (Appendix 1: *Suitability*).

Each suitability map highlights high, moderate and low suitability zones for a given resource at a specific interval. The results inform our understanding of resource interactions, forming the primary input for the interaction maps.

Figure 42, Figure 43, Figure 44, and Figure 45 show the suitability maps for the Lower Permian to the Cenozoic intervals.

Figure 46 presents the proportion of each stratigraphic interval that is moderately or highly suitable for specific subsurface resources, based on the suitability maps. The bar charts allow for the direct comparison of resource occurrence across intervals. They illustrate how the availability and distribution of petroleum, CGS, UGS, geothermal, and groundwater change with depth. The distribution of moderate to high suitability across resources reveals distinct patterns of potential use and competition within each stratigraphic interval.

In the Lower and Upper Permian intervals (G1low and G1up, Figure 46), petroleum and CGS both show extensive spatial presence (over 40% of the interval), with geothermal resources also showing significant occurrence (up to 24% of the interval G1up). This co-occurrence increases the likelihood of competition for pore space among these resources. Groundwater is absent in these deeper intervals, therefore no interactions are expected. In the Triassic-Lower Jurassic interval (G2A1), petroleum and CGS show extensive spatial presence, while groundwater appears in around 15% of the interval, suggesting some potential for interactions. However, Figure 44D suggests that the groundwater resource in this interval is geographically isolated from the other resources. In contrast, the younger intervals (A2, abA2 Leederville Parmelia, and abA2 Superficial) are dominated by groundwater, with minimal or no suitability recorded for other subsurface resources. Appendix 2: *Suitability maps description* includes a description of each suitability map.

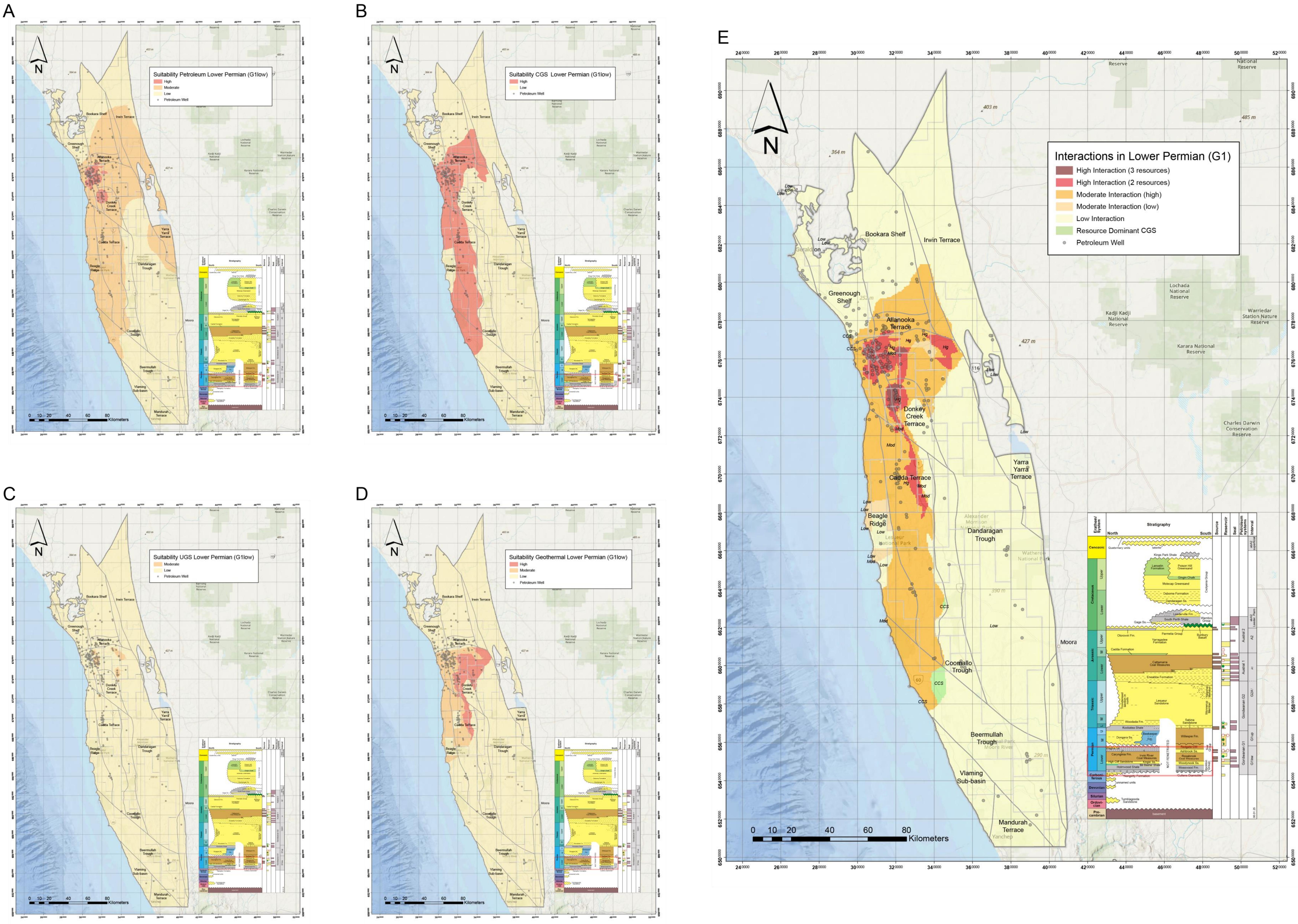


Figure 42. Suitability and interaction maps for the Lower Permian (G1low) interval (descriptions are available in Appendix 2 and Appendix 3): A) petroleum suitability map, B) CGS suitability map, C) UGS suitability map, D) geothermal suitability map, E) interaction map.

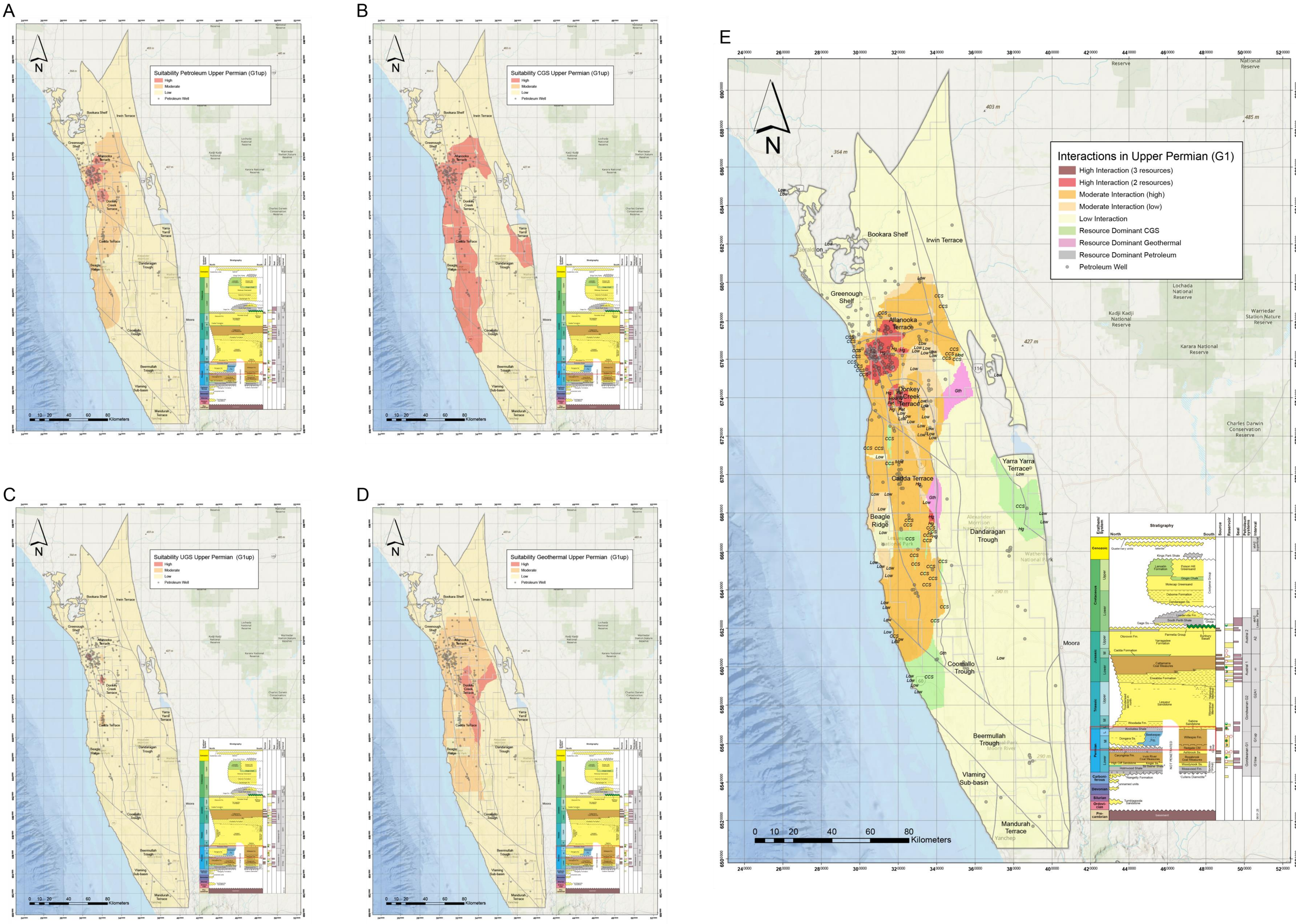


Figure 43. Suitability and interaction maps for the Upper Permian (G1up) interval (description available in Appendix 2 and Appendix 3): A) petroleum suitability map, B) CGS suitability map, C) UGS suitability map, D) geothermal suitability map, E) interaction map.

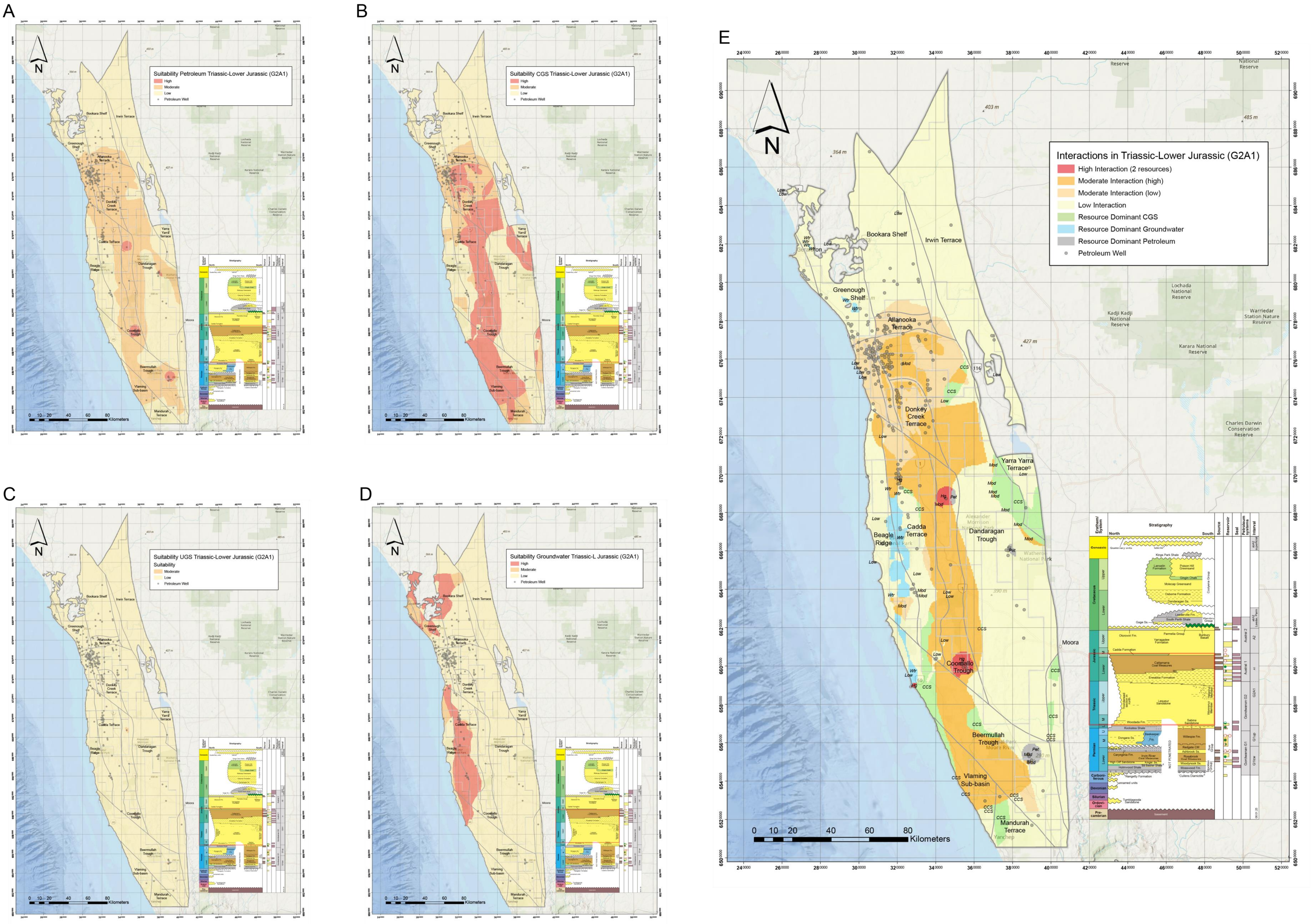
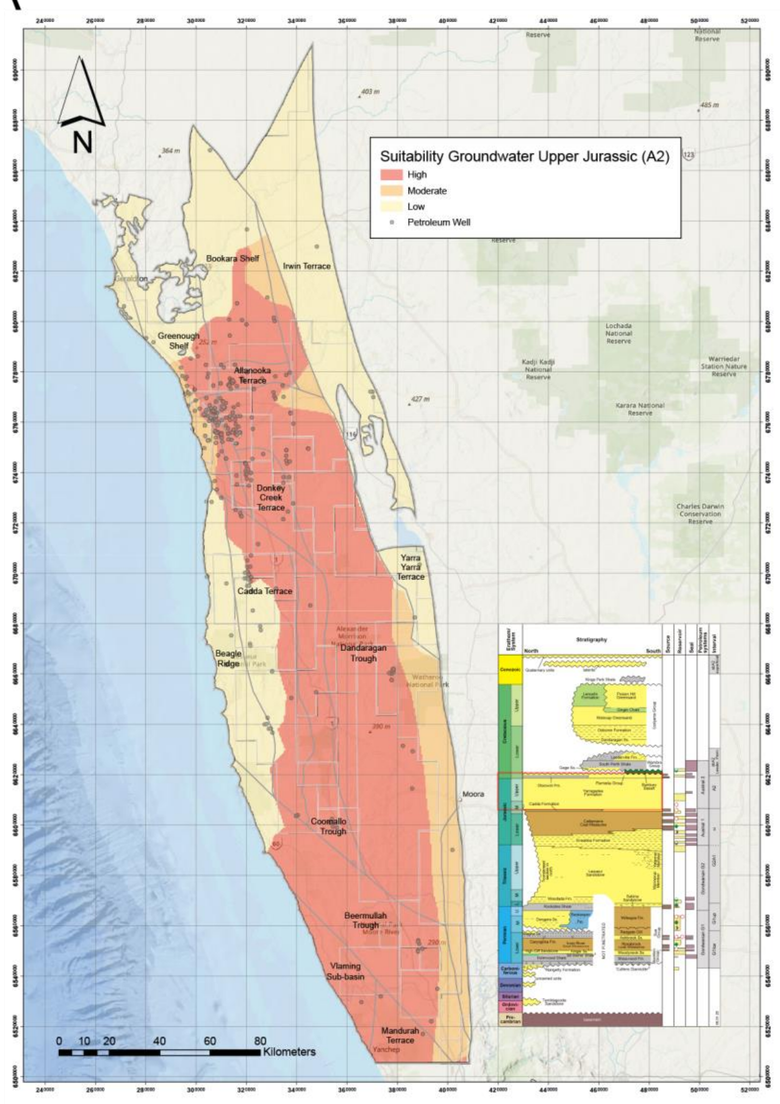
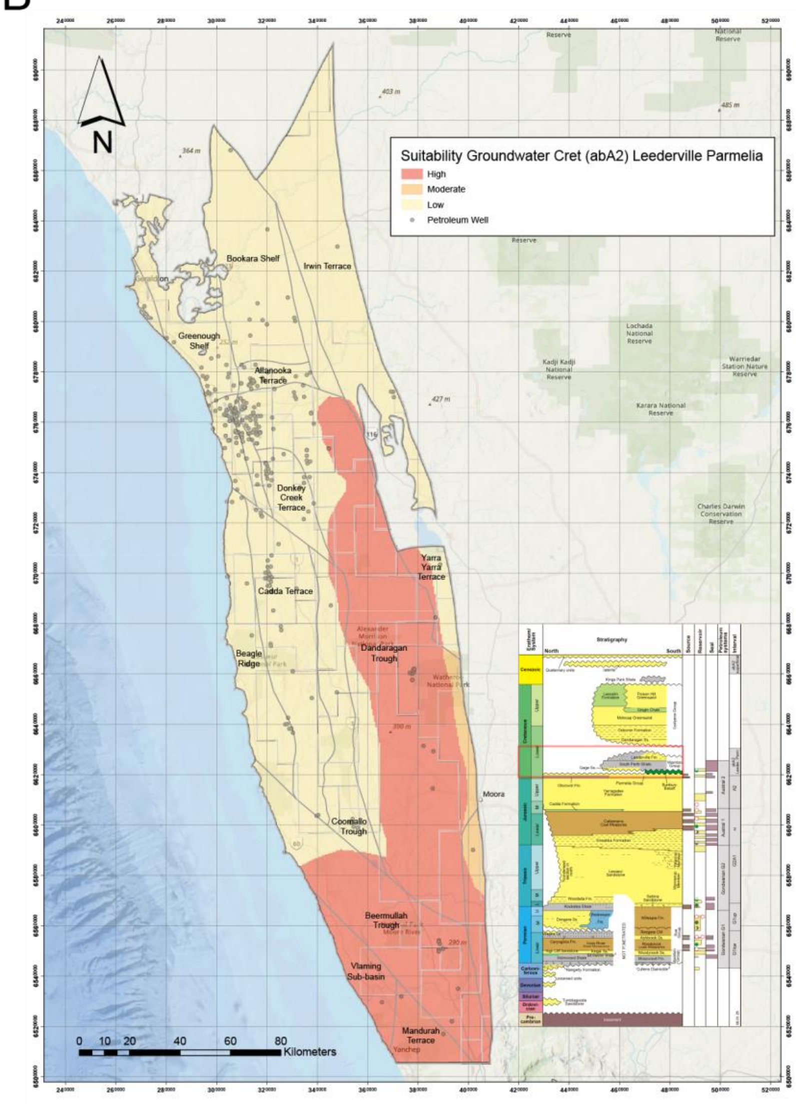


Figure 44. Suitability and interaction maps for the Triassic – Lower Jurassic (G2A1) interval (description in Appendix 2 and Appendix 3): A) petroleum suitability map, B) CGS suitability map, C) UGS suitability map, D) groundwater suitability map, E) interaction map.

A



B



C

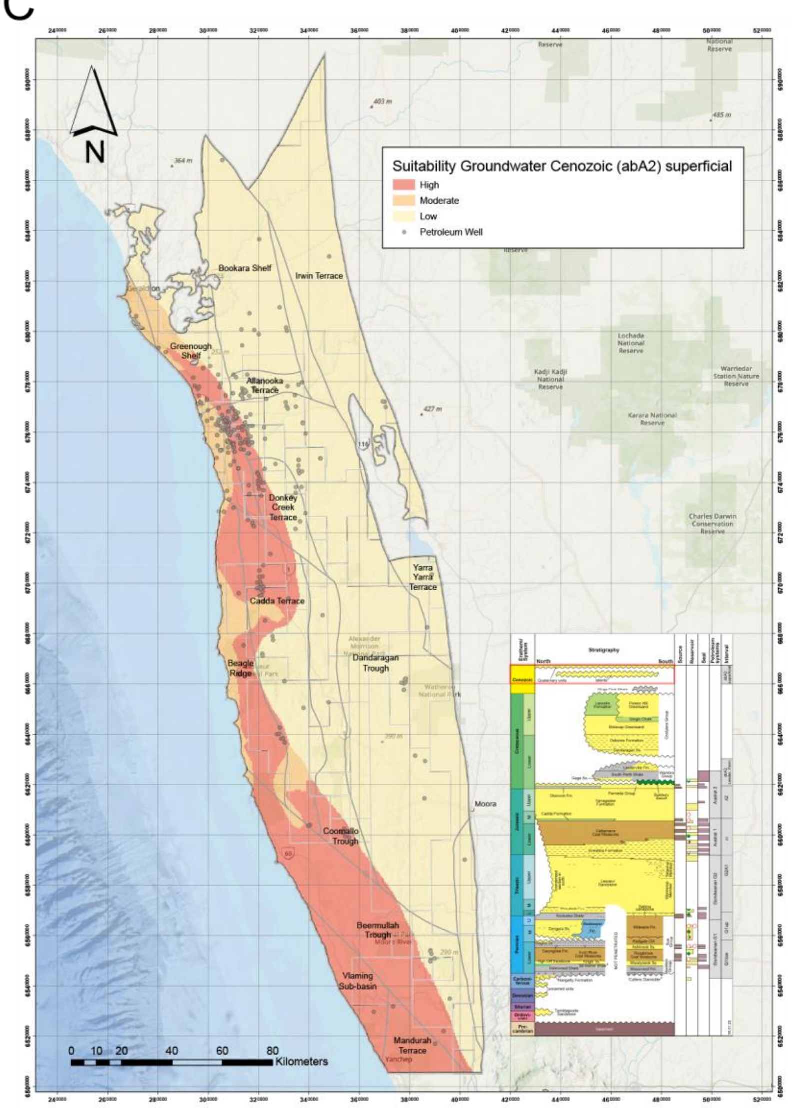


Figure 45. Suitability maps for the groundwater for the Upper Jurassic to Cainozoic intervals (description in Appendix 2): A) Yarragadee aquifer, Upper Jurassic suitability map (A2), B) Leederville-Parmelia aquifer, Lower Cretaceous suitability map (abA2), C) superficial aquifer, Cainozoic suitability map (abA2).

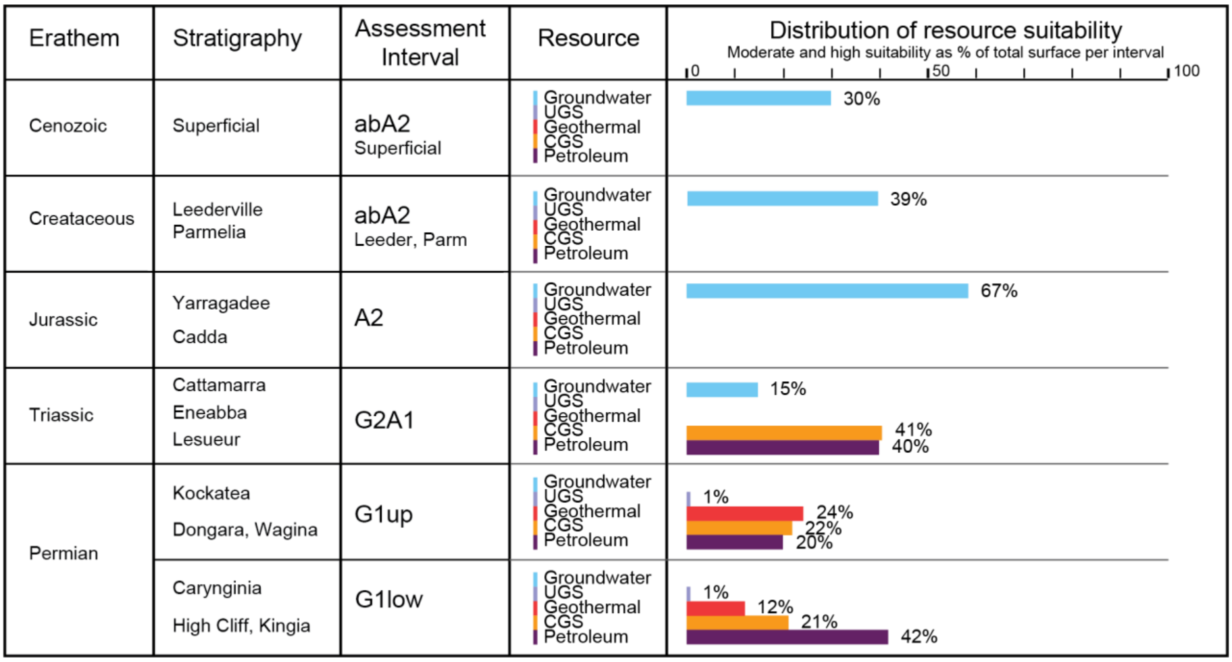


Figure 46. Distribution of resource with moderate to high suitability across assessment intervals.

4.1.2. Interaction maps

The interaction maps (Figure 19) illustrate the spatial relationships between subsurface resources across different stratigraphic intervals. They depict interactions between petroleum, CGS, geothermal, UGS, and groundwater resources to identify areas where resource development may compete or overlap.

Figure 42E, and Figure 43E show the interaction maps from the Lower Permian to the Cenozoic intervals. Appendix 3: *Interaction maps description* includes a detailed description of each suitability map.

The interaction between subsurface resources in the northern Perth Basin varies across stratigraphic intervals, with CGS and petroleum consistently emerging as the most dominant interacting resources. Across all 3 intervals Figure 42E, Figure 43E and Figure 44E), CGS frequently co-occurs with petroleum, reflecting their shared reliance on similar storage formations and sealing units. Geothermal and UGS play a secondary role, appearing more in moderate interaction areas rather than high-interaction zones.

The Lower and Upper Permian intervals (Figure 42E and Figure 43E) exhibit the highest interaction intensities, where CGS and petroleum strongly overlap. This reinforces the potential to repurpose petroleum reservoirs for CO_2 storage. In the Lower Permian interval, CGS is the most dominant interacting resource, while in the Upper Permian interval, petroleum is more prominent.

The Triassic-Lower Jurassic interval (Figure 44E) presents the lowest overall interaction intensity, though CGS and petroleum remain the key interacting resources. Groundwater appears in this interval but has limited overlap with deeper resources, suggesting that interaction risks are generally low. However, local structural features could create pathways that require careful management.

Resource dominance is limited across all intervals, with CGS being the most dominant resource occurring independently of other subsurface uses. This suggests that, in certain locations, CGS suitability is high enough to be considered a primary underground use, independent of petroleum or UGS.

In simple terms, CGS and petroleum are the most significant interacting resources across all intervals, frequently overlapping in shared geological formations. While interaction intensities vary, the overall pattern reinforces the need for integrated resource management to balance petroleum extraction, CO_2 storage and groundwater protection. Understanding these interactions can help minimise conflicts and optimise long-term subsurface resource use.

Description of interactions for the Lower Permian interval (G1low)

The Lower Permian interval (Figure 42E) is characterised by strong interactions between CGS and petroleum, as they frequently share the same underground storage formations. CGS is the most dominant interacting resource in high-interaction cases, appearing in 93% of cases, followed by geothermal resources (64%) and petroleum (52%). This highlights the significant overlap between these energy resources, which could influence future development strategies.

Moderate interactions are far more common than high interactions (24% vs 4%), indicating that indirect resource competition is more prevalent than direct high-intensity overlaps. Petroleum is the dominant resource in moderate interactions, appearing in 100% of cases, followed by CGS (84%) and geothermal resources (43%). The most frequent interaction combination (57%) in this category is petroleum (moderate suitability) and CGS (high suitability), showing that these 2 resources remain closely associated even in lower suitability zones.

Resource dominance is rare, accounting for only 0.5% of all interactions, with CGS as the only dominant resource. This suggests that no single resource overwhelmingly controls the Lower Permian interval, reinforcing the need for integrated subsurface planning.

In summary, CGS and petroleum interact the most in the Lower Permian interval because they depend on the same underground structures for storage and extraction. High-interaction zones are mostly found in Dandaragan Trough, Beharra Springs Terrace, Donkey Creek Terrace and Dongara Terrace, where CGS and petroleum frequently overlap. No groundwater resource is present in the Lower Permian interval. Understanding these interactions can help inform strategies for managing underground space, allowing different energy uses (such as oil extraction and CO_2 storage) to be developed in a coordinated and compatible manner.

Description of interactions for the Upper Permian interval (G1up)

The Upper Permian interval (Figure 43E) is characterised by strong interactions between petroleum and CGS, with petroleum appearing in 97% of all high-interaction cases. CGS (87%) and geothermal resources (11%) also play significant roles, though geothermal has a lesser influence in direct high interactions. These trends suggest that petroleum and CGS continue to share underground space, reinforcing the importance of coordinated planning.

Moderate interactions are more frequent, accounting for 21% of all interactions, and are mostly Petroleum-dominated. The most common moderate interaction combination (42%) is petroleum (moderate suitability), CGS (high suitability), and geothermal (moderate suitability), indicating that geothermal resources play a stronger role in moderate suitability zones compared to high-interaction areas.

Resource dominance is observed in 6% of cases, with CGS being the most dominant resource. This suggests that in certain areas, CGS suitability is high enough to be considered a primary underground use, independent of other resources.

Overall, petroleum and CGS have the strongest interactions in this interval, with geothermal resources playing a more moderate role compared to petroleum and CGS. High-interaction zones align with known oil and gas accumulations, reinforcing the need for integrated management of CO_2 storage and petroleum production. Understanding these interactions can help balance future energy extraction, carbon storage, and potential geothermal development in the Upper Permian interval.

Description of interactions for the Triassic-Lower Jurassic interval (G2A1)

Overall, the Triassic-Lower Jurassic interval (Figure 44E) presents lower interaction intensity compared to the Permian interval, with high-interaction cases accounting for only 0.7% of all interactions. CGS is the dominant resource in high-interaction zones (100%), reinforcing its role as a primary subsurface use. Petroleum (97%) also plays a significant role, while groundwater (3%) has limited direct overlap with other resources.

Moderate interactions are more common (31%), with petroleum and CGS being the most frequently co-occurring resources. The most common moderate interaction combination (68%) is petroleum (moderate suitability) and CGS (high suitability), showing that CGS remains a key factor in defining underground use in this interval.

Resource dominance is present in 6% of cases, with CGS being the most dominant resource. This suggests that while CGS is a major player, it does not completely control subsurface use in this interval.

Simply put, this interval has fewer high-interaction areas than the Lower and Upper Permian intervals, with CGS and petroleum continuing to be the most significant resources. No geothermal resource is present in the Triassic-Lower Jurassic interval. Groundwater has minimal overlap with other subsurface resources, but where it does interact, it requires careful management to ensure resource compatibility. Understanding these interactions can help balance petroleum development, CO_2 storage, and groundwater protection in the Triassic-Lower Jurassic intervals.

4.1.3. Thematic interaction maps

The thematic interaction maps (Figure 19) highlight areas of high and moderate suitability for specific resources, as well as interactions with other resources. These maps provide a more detailed, granular view of resource interaction patterns across different intervals.

Figure 47 shows the thematic interaction maps from the Lower Permian to Lower Jurassic intervals. Appendix 4: Thematic interaction maps description includes a detailed description of each interaction map.

Description of petroleum interactions for the Lower Permian interval (G1low)

Petroleum in the Lower Permian interval (Figure 47A) always interacts with at least one other resource, most frequently CGS (86%), followed by geothermal resources (30%). This strong correlation with CGS suggests that many historical petroleum fields could be viable for future CO_2 storage projects.

Moderate suitability petroleum covers a large portion of the basin (41%), with 48% interacting with CGS and 27% interacting with geothermal resources. However, 18% of moderate suitability petroleum occurs in isolation, indicating the presence of some standalone hydrocarbon zones.

In other words, petroleum in this interval is almost always linked to CGS, reinforcing the potential for repurposing oil and gas fields for CO_2 storage. Understanding these interactions is key to managing the transition between fossil fuel extraction and carbon sequestration, ensuring a balance between resource use and emissions reduction.

Description of CGS Interactions for the Lower Permian interval (G1up)

CGS in the Lower Permian interval (Figure 47B) interacts significantly with petroleum, with 98% overlap of high suitability CGS areas with petroleum zones. This highlights the strong geological link between CGS and petroleum reservoirs, as they often share the same storage formations and sealing units. Geothermal resources play a secondary role, interacting with 41% of high suitability CGS areas.

A small portion (2%) of high suitability CGS areas do not exhibit interactions, mainly in the Cadda Terrace and Beermullah Trough, suggesting some potential for independent storage sites.

Put simply, CGS in the Lower Permian interval is almost always found alongside petroleum, reinforcing the need for careful planning when repurposing former oil and gas fields for CO_2 storage. Understanding these interactions is essential for balancing hydrocarbon extraction with long-term carbon storage goals.

Description of petroleum interactions for the Upper Permian interval (G1up)

Petroleum in the Upper Permian interval (Figure 47C) interacts most frequently with geothermal resources (95%) and CGS (80%), indicating significant overlap between hydrocarbon reservoirs, CO_2 storage potential and geothermal energy sources. These interactions are strongest in Allanooka Terrace, Dongara Terrace, Beharra Springs Terrace, Dandaragan Trough and Donkey Creek Terrace, where known oil and gas accumulations align with high geological suitability for other resources.

Despite these overlaps, 0.4% of high-suitability petroleum areas exist without interactions, indicating that, while rare, some independent hydrocarbon zones remain.

In simple terms, petroleum in this interval is closely linked to both CGS and geothermal resources, meaning future energy projects must consider how oil and gas extraction, CO_2 storage and geothermal development can coexist. Understanding these interactions is critical to optimising subsurface resource use while ensuring sustainable energy development.

Description of CGS interactions for the Upper Permian interval (G1up)

The Upper Permian interval (Figure 47D) shows a strong interaction between CGS, geothermal resources and petroleum, with 61% of high suitability CGS areas overlapping with geothermal resources and 55% with petroleum. The moderate proportion of isolated CGS zones (20%) suggests that some areas remain geologically distinct, offering potential standalone storage opportunities.

Put simply, CGS in the Upper Permian interval is highly connected to both geothermal and petroleum resources, meaning they often coexist in the same geological formations. Any future CGS storage or geothermal development must consider these overlaps to ensure efficient resource management. Understanding these interactions is critical for optimising underground storage while balancing energy production and carbon storage goals.

Description of petroleum interactions for the Triassic-Lower Jurassic interval (G2A1)

The Triassic-Lower Jurassic interval (Figure 47E) exhibits lower interaction intensity than the Permian intervals, with petroleum interacting with CGS in 61% of high suitability cases and 78% in moderate suitability zones. Unlike deeper layers, 37% of high suitability petroleum is found in isolation, indicating more localised accumulation patterns.

In other words, petroleum in this interval has fewer high interactions than in the Permian interval, but still shares significant overlap with CGS. The limited interaction with groundwater suggests lower risk to water resources, though any CGS or oil development in this zone must still be managed carefully. Understanding these interactions is essential for ensuring the sustainable development of petroleum and CGS while protecting groundwater supplies.

Description of CGS interactions for the Triassic-Lower Jurassic interval (G2A1)

CGS in the Triassic-Lower Jurassic interval (Figure 47F) continues to interact predominantly with petroleum (81%), but with minimal interaction with groundwater (1%). The 19% of isolated high suitability CGS areas suggest that there are pockets of potential standalone storage sites that are less likely to be influenced by extraction of other resources.

In simple terms, CGS in this interval shares underground space mostly with petroleum, while its overlap with groundwater is limited. This means that CGS storage sites in this interval may pose less risk of water contamination, making them more favourable for long-term CO_2 storage. Understanding these interactions is crucial for selecting optimal CGS storage locations and ensuring they do not interfere with existing petroleum or water resources.

Description of groundwater interactions for the Triassic-Lower Jurassic interval (G2A1)

Groundwater in the Triassic-Lower Jurassic interval (Figure 47G) is largely independent of other subsurface resources, with 66% of high suitability groundwater areas having no interaction. When interactions do occur, they are mostly with petroleum and CGS (23% each), highlighting the potential for hydrocarbon development and CO_2 storage to impact groundwater systems in specific locations.

The Beagle Ridge, Cadda Terrace and Beermullah Trough contain the largest isolated groundwater zones, where no interaction is observed. These areas may represent important groundwater reserves that should be protected from subsurface development.

In summary, groundwater in this interval is mostly separate from other subsurface resources, but where it overlaps with petroleum and CGS, careful planning is needed to protect water quality. Understanding these interactions is crucial for ensuring safe groundwater management while balancing energy and storage needs.

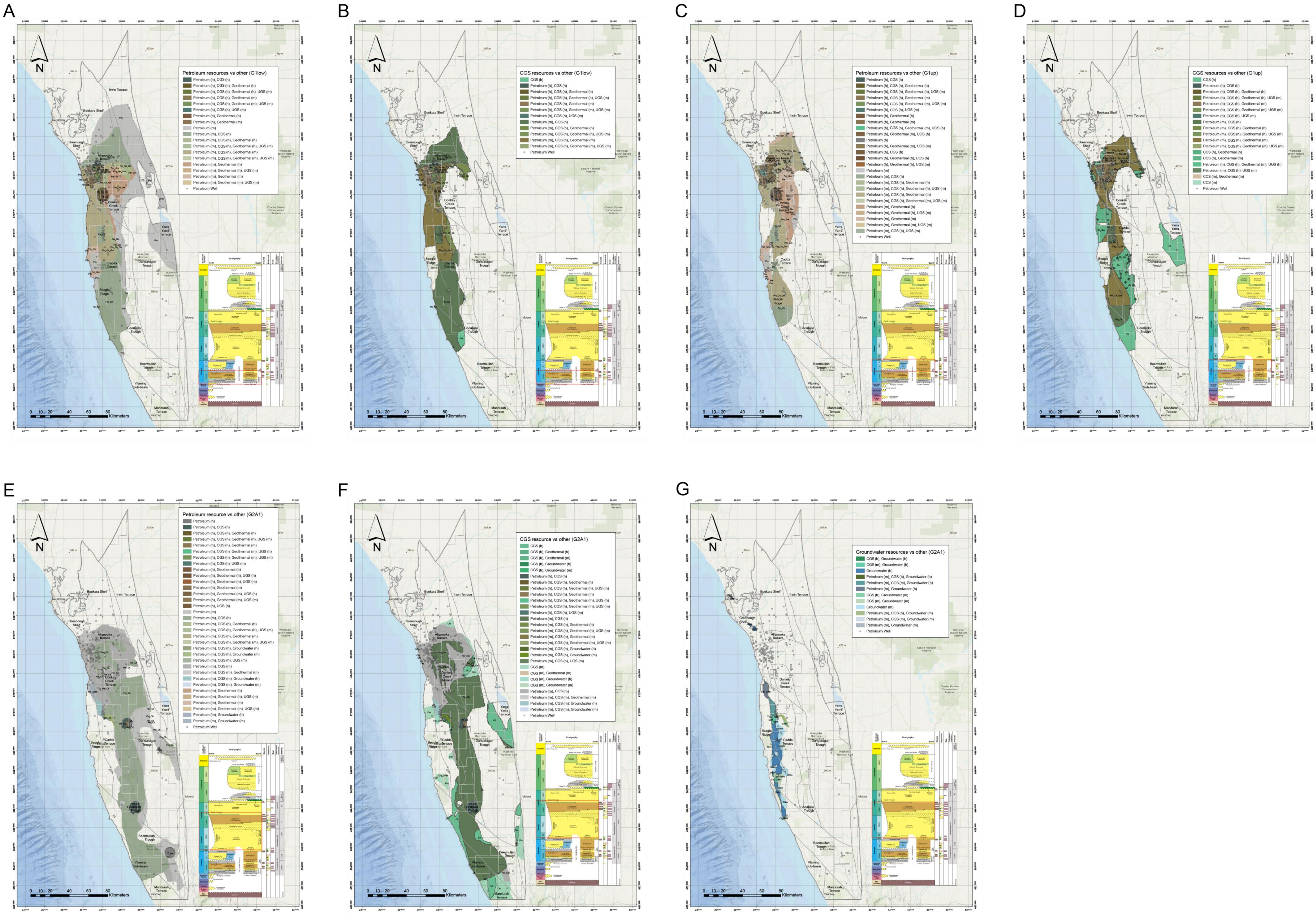


Figure 47. Thematic interaction maps (description available in Appendix 4). On the maps, the resources are labelled P (petroleum), C (CGS), G (geothermal), U (UGS), GW (groundwater), h (high suitability), and m (moderate suitability). A) Interaction with petroleum resources in the Lower Permian interval (G1low), B) interaction with CGS resources in the Lower Permian interval (G1low), C) interaction with petroleum resources in the Upper Permian interval (G1up), D) interaction with CGS resources in the Upper Permian interval (G1up), E) interaction with petroleum resources in the Triassic-Lower Jurassic interval (G2A1), F) interaction with CGS resources in the Triassic-Lower Jurassic interval (G2A1), and G) interaction with groundwater resources in the Triassic-Lower Jurassic interval (G2A1).

4.1.4. Cumulative interaction map

The cumulative interaction map (Figure 48) aggregates interaction data across 3 stratigraphic intervals (Lower Permian (G1low), Upper Permian (G1up), and Triassic-Lower Jurassic (G2A1)). It provides a basin-wide view of potential competition between deep subsurface resources, including petroleum, CGS, UGS, geothermal energy and (to a lesser extent) groundwater. By combining resource suitability across intervals, the map highlights areas where multiple subsurface uses may coexist or conflict.

Overall, high-interaction zones represent approximately 5% of the basin. These areas are dominated by petroleum and CGS suitability, and typically correspond to shared structural traps and reservoir-seal systems. This reinforces the geological connection between hydrocarbon accumulations and future CO_2 storage potential. Moderate interaction zones, representing 20% of the basin, form a buffer around the high-interaction clusters and are more strongly associated with geothermal and UGS suitability. These areas present opportunities for alternative resource development but may still require coordinated planning to avoid indirect competition.

Spatially, the most prominent high-interaction cluster is located east and southeast of Dongara, covering the Allanooka Terrace, Dandaragan Trough, Beharra Springs Terrace, Dongara Terrace, and Donkey Creek Terrace. This area aligns with historical petroleum fields and infrastructure in Permian reservoirs. An elongated high-interaction corridor extends south through the Cadda Terrace, Coomallo Trough and Beermullah Trough, where co-suitability for petroleum and CGS is also high. The moderate interaction belt surrounds these high-stress areas and includes zones such as the Wicherina Terrace, Bookara Shelf, Greenough Shelf, Beagle Ridge and Yarra Yarra Terrace.

These observed patterns suggest that legacy petroleum areas, east and southeast of Dongara, could serve as key locations for future CGS projects. They also highlight the importance of managing overlapping resource claims. The broader moderate interaction belt offers flexibility for alternative resource use, but still warrants case-by-case evaluation. While groundwater plays a limited role in this particular map (Figure 48), the presence of deep resource interactions beneath major aquifers emphasises the importance of considering potential soft interactions, especially in areas where vertical migration pathways may be present.

4.1.5. Integrated maps

To enhance the assessment of subsurface resource interactions, 2 additional factors have been integrated into the cumulative interaction map: groundwater demand and potential migration pathways. The resulting integrated cumulative interaction maps (Figure 49 and Figure 50) offer a more comprehensive view of resource pressure zones, particularly in areas where deep energy resources may have an indirect impact on groundwater systems. This includes both demand-driven stress (where resource development overlaps with intensive groundwater use) and ‘soft’ interactions (see methodology, integrated cumulative interaction maps), where deep and shallow resources may be connected via vertical pathways such as faults or petroleum wells. The 2 integrated map types (groundwater demand and migration pathways) highlight areas where such interactions are more likely.

Groundwater demand

To evaluate where groundwater extraction and deep subsurface resource development may coincide, the cumulative interaction map was combined with bore density data, serving as a proxy for groundwater use intensity. This reveals dual-resource stress zones, where both energy development and water demand may compete (Figure 49).

Key areas of concern include:

- Inland of Dongara (Figure 49C), where regions of high-interaction overlap directly with high bore density (Figure 49A and B).
- East of Leeman (Figure 49C), where groundwater demand intersects with a corridor of high deep resource suitability along the Cadda Terrace.

Migration pathways

To assess the potential for vertical connectivity between deep and shallow systems, a second set of integrated maps incorporates structural features and well infrastructure as possible migration pathways. These include:

- Faults displacing the Cadda and Kockatea seals, which may juxtapose deep reservoirs with overlying aquifers and/or where damage zones with increased structural permeability could facilitate vertical fluid movement (Faulkner *et al.,* 2010) (Figure 50A).
- Petroleum wells penetrating Permian reservoirs, which could act as conduits for vertical fluid movement (Figure 50B).

A major convergence of faults and high well density occurs inland of Dongara, across the Donkey Creek, Beharra Springs and Dongara Terraces (Figure 50A and Figure 50B). A secondary zone of concern lies along the Cadda Terrace, where large faults could compromise seal integrity (Figure 50A and Figure 50B).

No site-specific well integrity or geomechanical assessments were conducted. All wells were treated uniformly, and no fault seal analysis was applied. This reinforces the first-order, basin-scale nature of the analysis. Nonetheless, the map provides a valuable tool for highlighting zones where deep resource development may require additional scrutiny due to potential migration risks.

Soft interaction to aquifers

To evaluate potential soft interactions between deeper resources and shallow groundwater, the pathway-integrated map (Figure 50D) was compared against major aquifer boundaries (Lesueur-Eneabba-Cattamarra, Yarragadee, Leederville-Parmelia and Superficial aquifers) (Figure 51). These aquifers include freshwater and saline or brackish zones, with salinities up to 14,000 mg/l (Department of Water, 2017).

The degree of overlap between migration pathways and aquifer distribution varies across the basin:

- **Lesueur-Eneabba-Cattamarra aquifer** (Figure **51**A)**:** Extends across the western-central portion of the basin, mostly overlapping moderate migration pathway zones and resource interaction zones, suggesting limited deep-shallow connectivity.

- **Yarragadee aquifer** (Figure **51**B)**:** Covers most of the northern Perth Basin, aligning with high and moderate migration pathway zones and resource interaction zones, indicating a greater likelihood of soft interactions if migration pathways exist.
- **Leederville-Parmelia aquifers** (Figure **51**C)**:** Located in the eastern and southern basin margins, primarily overlapping low to moderate migration pathway zones and resource interaction zones, suggesting minimal connectivity to deep resource units.
- **Superficial aquifer** (Figure **51** D)**:** Found along the coastal regions from Greenough Shelf to Mandurah Terrace, exhibiting variable overlap with high to low migration pathway zones, reflecting spatially dependent soft interaction potential.

These integrated analyses do not confirm active fluid migration, but rather, highlight areas where geological and well infrastructure features could facilitate interactions between deep resources and shallower aquifers. Future assessments should incorporate high-resolution structural models, well integrity assessments and site-specific hydrogeological data to refine predictions of potential migration risks and resource coexistence.

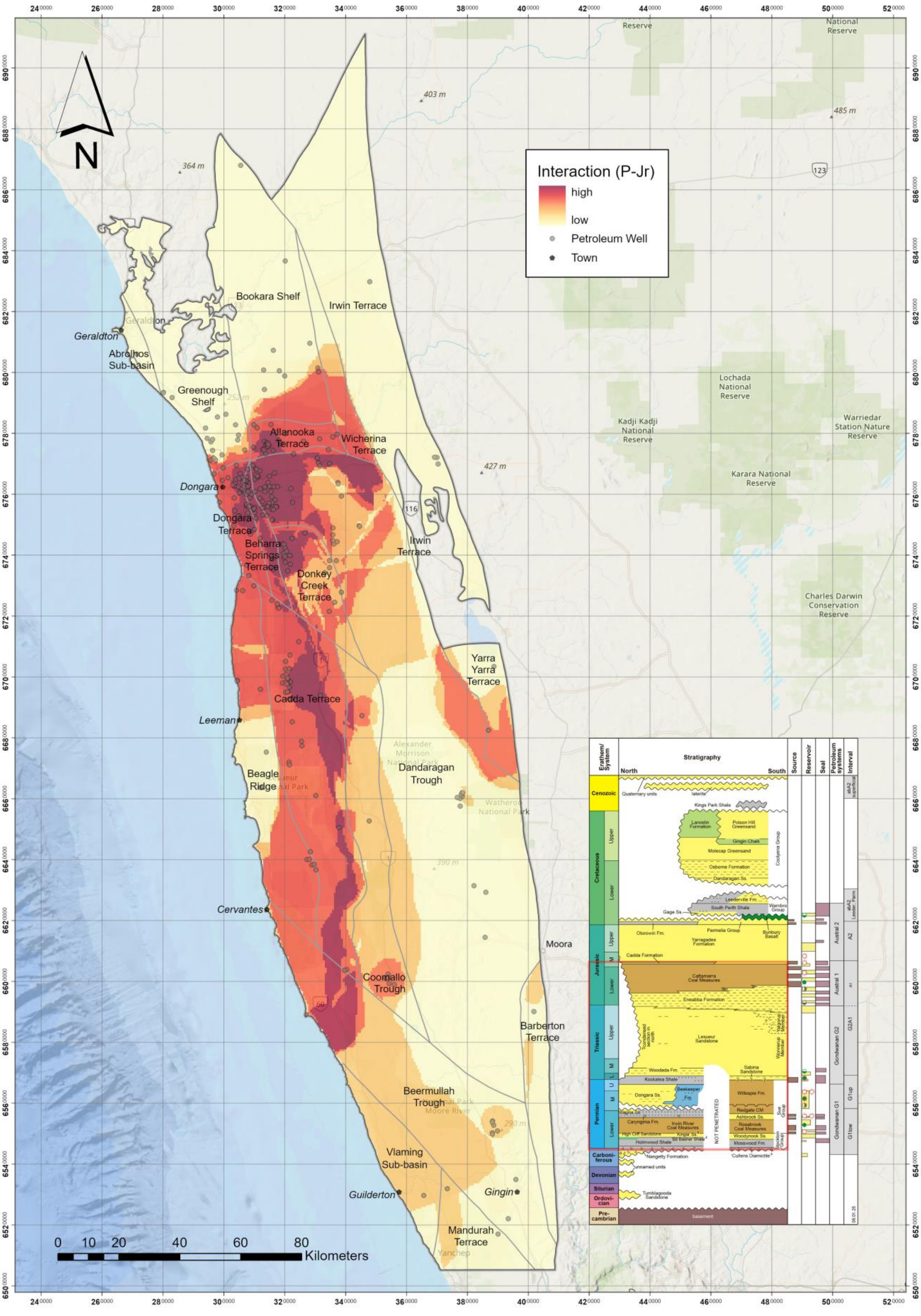


Figure 48. Cumulative interaction map for the Lower Permian-Lower Jurassic intervals (G1low, G1up, G2A1).

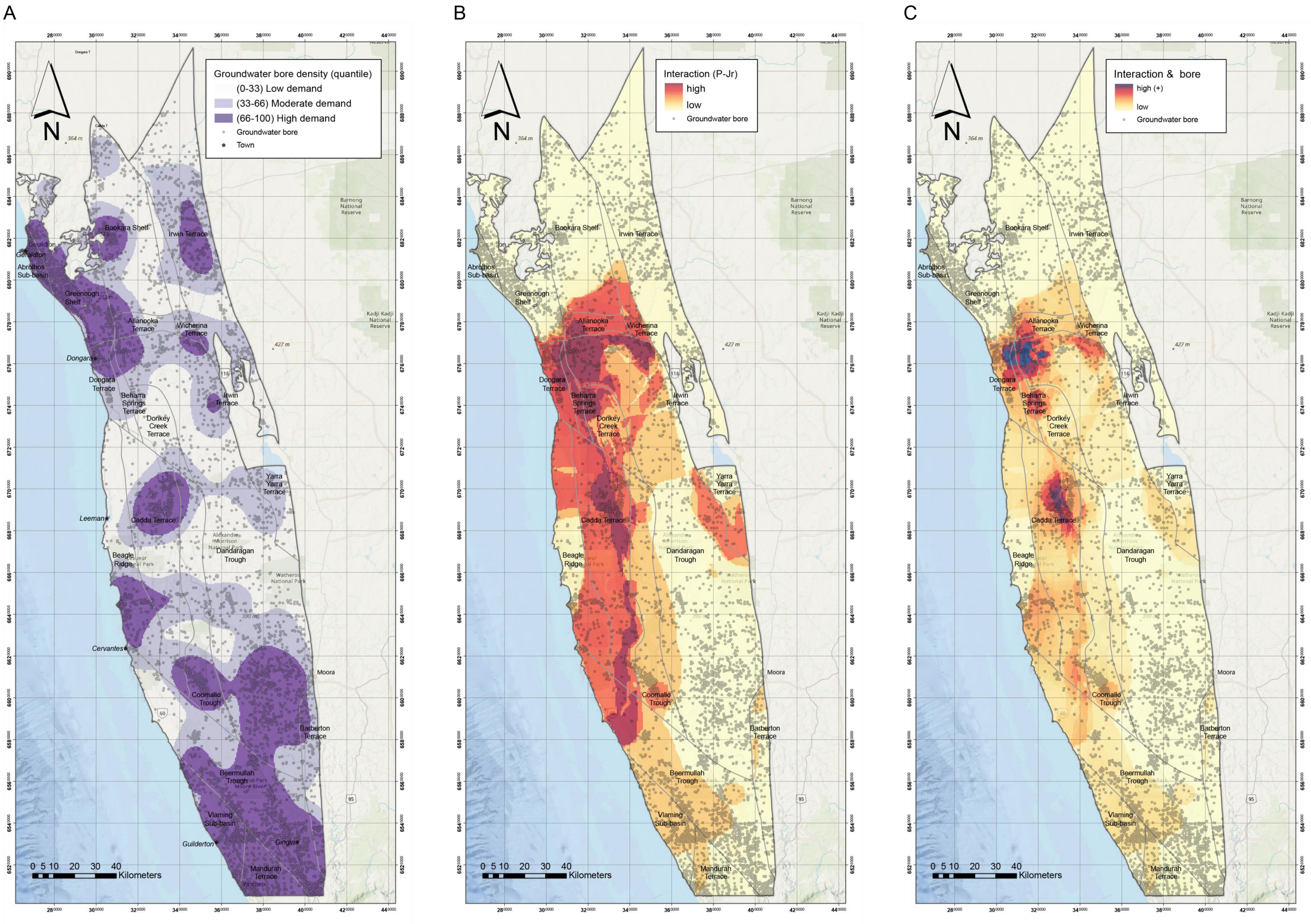


Figure 49. Integration of groundwater demand and resource cumulative interaction. A) Groundwater bore distribution and density (shown as quantiles), used as proxy for water usage, B) cumulative interaction map (Figure 48) and groundwater bores, C) integrated map, interaction and bore; bore density is reclassified and used to adjust the deep resource cumulative interactions for water use intensity. Warmer colours indicate a higher potential for dual-resource stress between deeper resources and shallow aquifers.

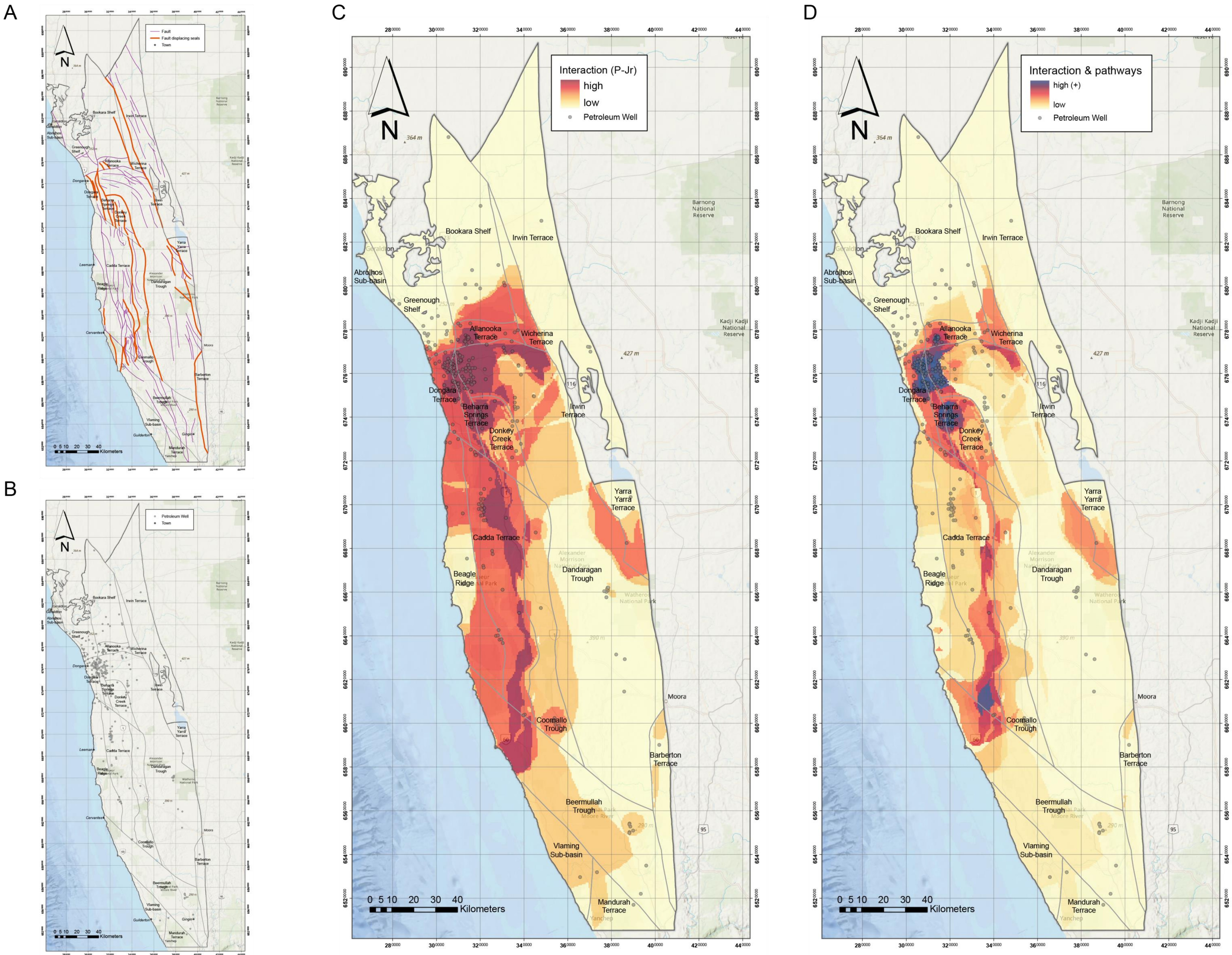


Figure 50. Integration of potential pathways and resource cumulative interaction. A) Distribution of faults potentially acting as migration pathways; regional faults (purple) and fault displacing the Cadda and Kockatea seals (red), B) distribution of petroleum wells potentially acting as migration pathways, C) cumulative interaction map, D) integrated map, interaction and pathways; pathway density is reclassified and used to adjust the deep resource cumulative interactions for pathways intensity. Warmer colours indicate a higher potential for vertical migration of deeper resources.

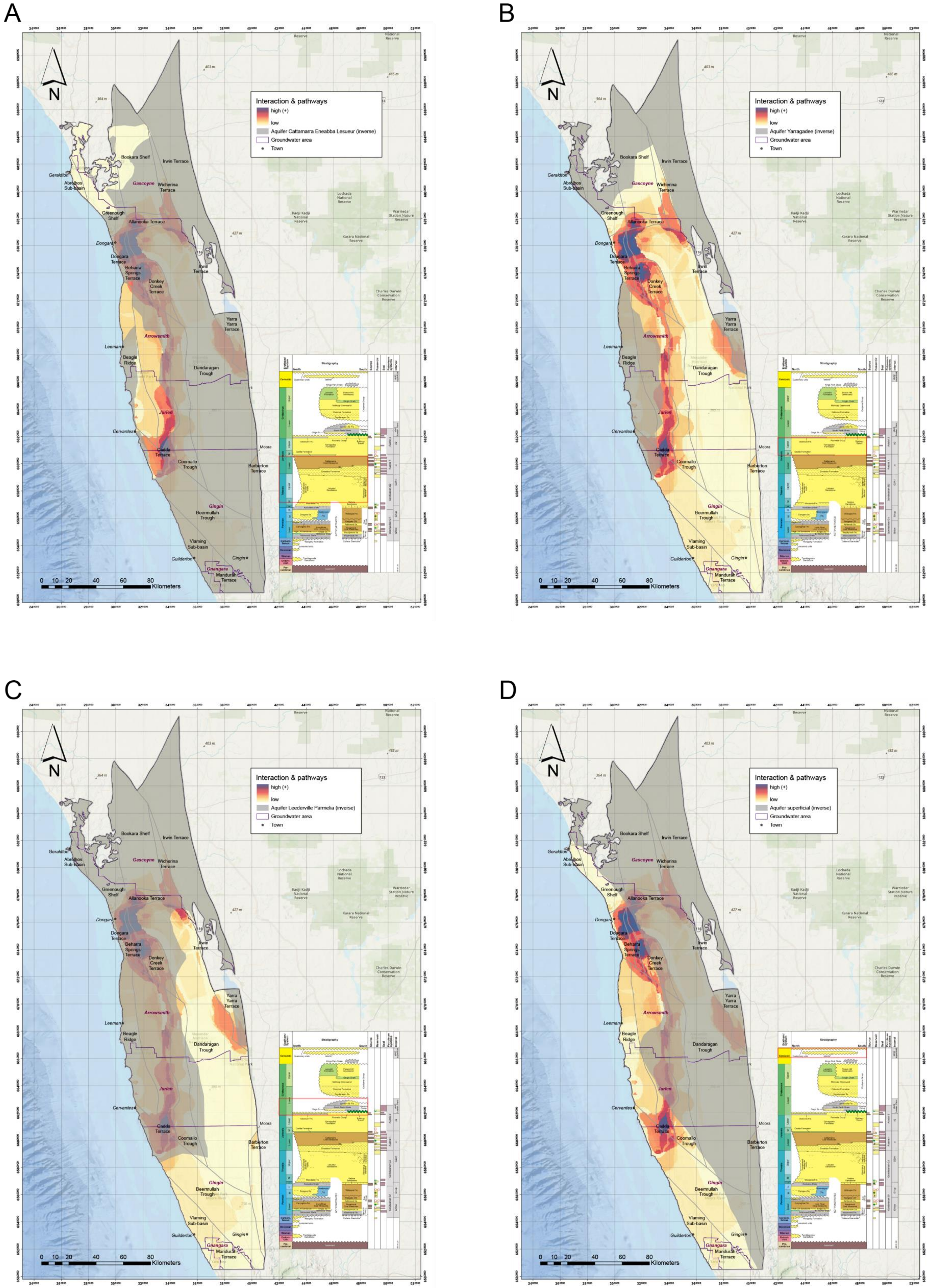


Figure 51. Potential soft interaction between Lower Permian-Lower Jurassic resources and aquifers. A) Cumulative interaction map and outline of Lesueur-Eneabba-Cattamarra aquifers, B) cumulative interaction map and outline of Yarragadee aquifer, C) cumulative interaction map and outline of Leederville-Parmelia aquifers, D) cumulative interaction map and outline of superficial aquifers.

Local evaluation: Dongara-Beharra Springs-Donkey Creek Terraces

The Dongara-Beharra Springs-Donkey Creek Terraces represent one of the most significant areas of resource interaction in the northern Perth Basin, aligning with the highest cumulative interaction anomalies observed in the cumulative interaction map (Figure 49 and Figure 52A). This also aligns with the high migration pathway density observed in the integrated map for migration pathways (Figure 50D, Figure 52B). This area exhibits strong correlations with interaction patterns in the Lower and Upper Permian intervals, where petroleum, CGS and UGS suitability strongly overlap, and geothermal suitability to a lesser extent (Figure 53). Gas production is the only purely extractive operation leading to under-pressures, particularly in fault compartments with no aquifer pressure support. This is the case for the depleted Dongara field, which is still severely under-pressured 10 years after production ceased. In this case, the resource overlap presents an opportunity for CO_2, natural gas or hydrogen storage. The compartmentalisation also provides some confidence that stored fluids remain within the structure and that there is a low risk of pressure impacts beyond the storage complex. However, the maximum storage volume and injection rates are constrained by the original reservoir pressure, which should not be exceeded to avoid fracture creation. Natural gas and hydrogen storage have regular injection-production cycles with no net pressure change, allowing for continuous operations. Contrastingly, CO_2 injection ceases once the pressure limit is reached.

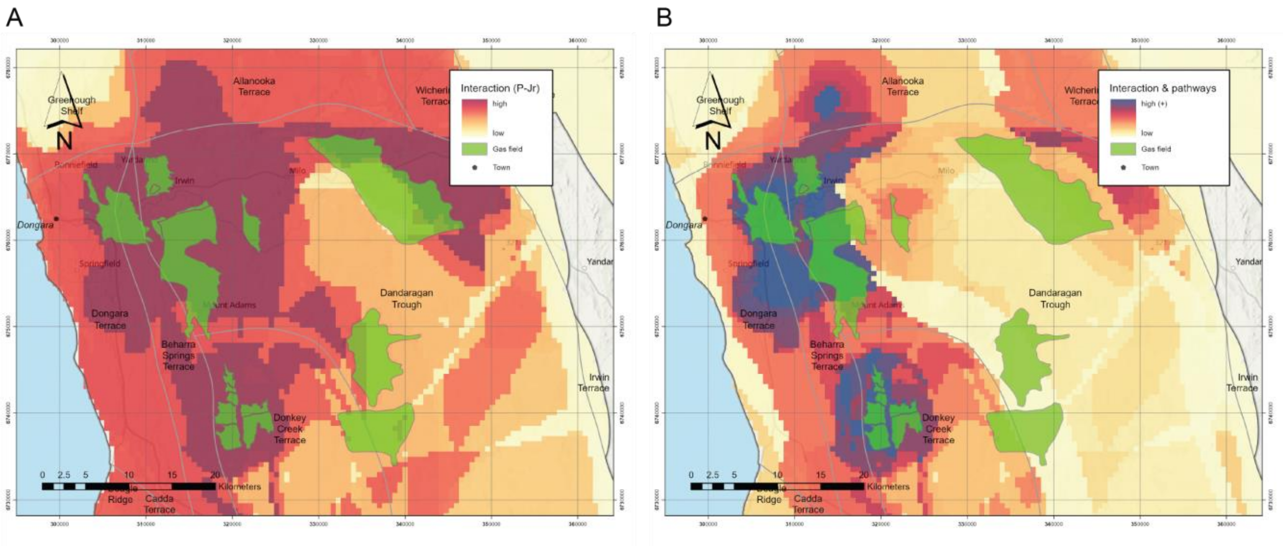


Figure 52. Dongara-Beharra Springs-Donkey Creek Terraces. A) Cumulative interaction map showing aggregated interaction data across Lower Permian-Lower Jurassic intervals, B) integrated map, interaction and pathways showing potential for vertical migration of deeper resources.

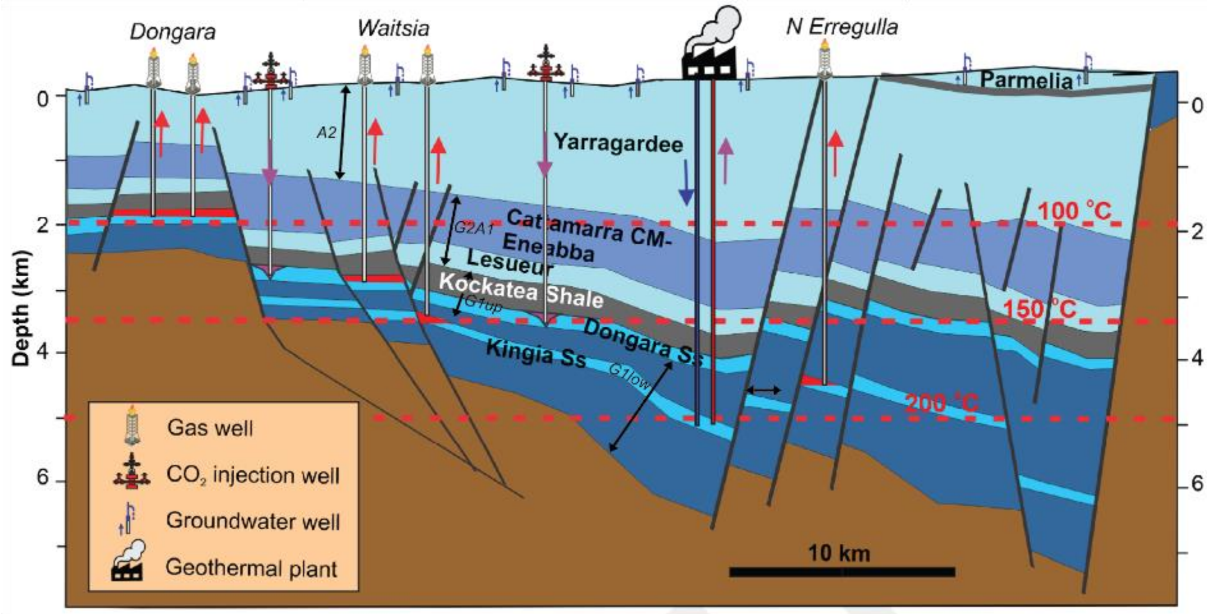


Figure 53. Diagrammatic west-east cross-section showing vertical temperature distribution and potential locations of future geothermal energy production and CO_2 injection in relation to existing gas fields.

4.1.6. Observed interaction patterns on Dongara-Beharra Springs-Donkey Creek Terraces

Lower Permian interactions (G1low)

This area contains some of the highest interaction zones in the Lower Permian interval. Petroleum and CGS suitability strongly coincide across this region, reinforcing its potential for repurposing depleted petroleum fields for CO_2 storage. UGS suitability is also concentrated here, as most of the highest-tier storage sites align with depleted petroleum fields, making this region a prime candidate for underground gas storage development. In contrast, geothermal suitability plays a minor role in the high-interaction areas, as it is primarily located to the east of the petroleum and CGS suitability zones.

Upper Permian interactions (G1up)

Interaction intensity remains high in the Upper Permian, with a continued overlap between petroleum, CGS, and UGS. The same geological structures that favour petroleum and CGS storage in the Lower Permian interval extend into this interval, contributing to the continuity of high-interaction zones. UGS suitability remains strong, further supporting the suitability of this area for gas storage in depleted reservoirs. Geothermal suitability, however, is limited in this part of the basin, indicating lower thermal potential compared to other intervals.

Cumulative interactions

The Dongara–Beharra Springs–Donkey Creek region stands out as one of the main cumulative interaction hotspots in the northern Perth Basin (Figure 52A). This area exhibits a high degree of subsurface resource overlap, making it a critical zone for integrated multi-resource planning and management. Reservoir and seal quality are key factors driving interaction intensity, particularly between CGS and petroleum. Permian reservoirs in this region are both widespread and overlapping, serving as viable storage formations for CO_2 and hydrocarbon accumulations alike. The regional Kockatea Shale provides a robust sealing unit, exceeding 100 metres in thickness, which ensures effective containment for both CO_2 storage and hydrocarbon retention.

Key takeaways

The Dongara-Beharra Springs-Donkey Creek Terraces represent a key area of subsurface resource overlap, where petroleum, CGS and UGS interact most intensely across the Lower and Upper Permian intervals. Reservoir quality is a primary driver of interaction intensity in this area, as both CGS and petroleum rely on the same porous formations for storage and extraction. Similarly, seal quality plays a critical role, with the thick and continuous Kockatea Shale ensuring effective containment of CO_2 and hydrocarbons.

Additionally, this region is overlain by the Yarragadee and Superficial aquifers. Faults and deep wells are highly concentrated where fault networks intersect. While deep and shallow subsurface systems are typically isolated, structural features may act as potential migration pathways. The extent of fluid movement between these intervals is controlled by fault permeability, basin evolution and vertical lithological variations, requiring further localised assessment to determine the likelihood of deep-shallow interactions.

This region is one of the most important zones for subsurface resource management, as it contains overlapping petroleum fields, CGS storage potential and UGS suitability. While its high-quality reservoirs and seals make it an optimal location for hydrocarbon production and gas storage, the presence of shallow aquifers and structural complexity suggests that potential migration pathways, and increasing deep-shallow interaction risk, must be carefully evaluated. These insights highlight that coordinated planning is needed in this region, particularly around Dongara, where petroleum production, CO_2 storage and gas storage are all technically viable and spatially overlap. Future energy projects should prioritise detailed site assessments to evaluate migration risks, manage potential resource competition and identify locations where resource coexistence is feasible without compromising groundwater protection.