SYNTHESIS - FINAL REPORT C36001

Project: C36001 Open Cut Mine Gas Drainage
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Synthesis Prepared by: ACARP Mine Site Greenhouse Gas Mitigation Committee
Report published: October 2026
Report available: www.acarp.com.au

KEYWORDS

Coal seam methane, fugitive methane emissions, open cut mining, gas pre-drainage, surface-to-in-seam drainage, highwall-to-in-seam drainage, coal permeability, desorbable gas content, methane mitigation.

SUMMARY

This study examines the drivers of feasibility of coal seam pre-drainage ahead of open cut mining, and whether it could materially reduce fugitive methane emissions. While well-established underground, pre-drainage is harder to transfer to open cut mining because it is multi-seam, spatially dynamic, and schedule sensitive.

This study considers two representative settings: the Hunter Valley coal measures in New South Wales, with emphasis on the Jerrys Plains Subgroup, and the Moranbah Coal Measures in Central Queensland, including the Goonyella Middle Seam. Differences in seam thickness, rank, gas content, gas composition, structure and seam multiplicity strongly influence feasibility.

Surface-to-in-seam (SIS) drainage is the main reference method considered. Conventional SIS is the most credible basis for further work because it is the most developed directional drainage method and has underground mining precedent. Reverse SIS may be workable in some seam geometries but is more constrained. Skewed SIS remains conceptual. Highwall-to-in-seam (HIS) drainage may offer access advantages, but it creates greater interaction with active open cut mining and is less attractive as a general solution.

Pre-drainage will not remove all gas from a coal seam. Some residual gas will remain, and the time needed to reduce gas content depends strongly on permeability, gas composition and saturation. Furthermore, draining selected seams will not necessarily address emissions from other coal seams and interburden within the mining sequence.

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The principal conclusion is that pre-drainage feasibility will vary widely, and (after detailed site-specific studies) may be identified as a potential abatement method for selected sites and seams, not as a ready-to-use or whole-of-mine solution. The strongest cases are likely where seams are thick enough to drill reliably, gas-rich, sufficiently permeable, and supported lead time, and backed by a stable mine plan.

Sensitivities

This study is conceptual and generic. Drainage layouts, illustrate possible system arrangements only. They should not be interpreted as demonstrating feasibility at any specific operation. Actual feasibility requires site-specific gas content, permeability, geological, hydrogeological, mine planning, and cost data.

Disclosure

This study relies on technical papers, personal files and industry/personal communications. Public data are incomplete, particularly for seam-by-seam gas content and permeability. The study therefore identifies the next phase of work rather than presenting an implementable design.

KEY POINTS

General

- Pre-drainage may be technically viable in selected open cut settings, but it is likely to be selectively applicable rather than broadly transferable across the sector.
- SIS is the most credible reference method for further assessment, although open cut use requires a different design philosophy from underground SIS.
- Any drainage system must be assessed as an integrated mine-planning, reservoir, infrastructure, and emissions-abatement problem.
- Gas revenue alone is highly unlikely to justify pre-drainage in many cases. The case depends on methane abatement value, avoided carbon-related costs, operational benefits, and total system cost.

Coal Seam and Reservoir Conditions

- Viability depends on seam thickness, desorbable gas content, permeability, gas composition, saturation, depth of cover, seam continuity, and geological structures.
- Depth of cover is a useful first-pass proxy for gas content, but not a reliable standalone predictor. Gas content and composition vary by seam, gas compartment, and local geological history.
- Gas-content is generally site-specific or interpreted by depth, domain or mining area.
- Permeability is even more site-specific in controlling flow rate, drainage lead time, and drainage effectiveness.

Open Cut Application of SIS

- Underground SIS usually targets a specific mining seam ahead of longwall extraction. Open cut mining commonly exposes multiple seams, splits, thin plies and carbonaceous interburden within the same sequence.
- A borehole in one seam will not normally drain separate seams or interburden unless a hydraulic connection exists. Multi-seam open cut drainage may therefore require multiple seam-specific targets, increasing cost and complexity.
- Many open cut seams may be too thin, discontinuous or numerous to justify drainage. A drillable seam does not necessarily justify drainage.

- SIS design must consider borehole length, spacing, trajectory, seam dip, seam undulation, water accumulation, maintenance, suction losses, and target residual gas content.

Drainage Design Options

- Conventional SIS is the simplest layout, using a surface build section, in-seam lateral, and vertical production well for water and gas recovery.
- Reverse SIS may assist where seam dip or surface constraints prevent a standard layout, but the production well must intersect the lateral near the build-section entry point, making the arrangement more constrained.
- Skewed SIS may allow boreholes to be retired progressively as mining advances, but remains conceptual and depends on drilling accuracy, grouting effectiveness, and mine-sequence alignment.
- HIS is a more disruptive variant because it places drilling and drainage infrastructure close to the active highwall, with implications for highwall stability, safety controls, mine scheduling, and pit progression.

Operational Interaction and Infrastructure

- Open cut pre-drainage requires surface infrastructure as well as boreholes, including wellheads, reticulation lines, water management, metering, flares, power, and access tracks.
- As mining advances, boreholes may need to be isolated, grouted, retired or removed to prevent air ingress and maintain safe mining conditions.
- Drainage infrastructure may sterilise ground, restrict haul roads and working areas, affect blasting and excavation, and reduce short-term planning flexibility.
- Water production, desilting, pump maintenance and monitoring are ongoing requirements. Longer lead times increase the likelihood of performance decline or failure.

Modelling, Performance and Cost

- Modelling is necessary but only useful where supported by reliable seam-specific data. Permeability is especially influential, and small changes can materially alter predicted lead time and gas recovery.
- Indicative modelling shows that permeability can materially alter drainage lead time and gas reduction. Under favourable assumptions, gas content may reduce substantially, but the result is illustrative rather than predictive of field performance.
- A full assessment should consider total system cost, including reticulation, gas handling, maintenance, water management, verification drilling, infrastructure interaction, mining delay and methane abatement value.

Gas handling and Abatement

- The primary objective in the open cut context is greenhouse gas abatement, not gas production for its own sake.
- Flaring is the simplest gas handling pathway and may provide the minimum practical abatement case by converting methane to carbon dioxide and water vapour.
- Power generation, gas conditioning, utilisation or pipeline export may recover more value, but depend on gas volume, gas quality, location, infrastructure access, and commercial context.
- Abatement claims require verification using pre- drainage gas characterisation data, gas capture data, destruction or utilisation data, and defensible attribution.

Key Challenges

- Long and uncertain drainage lead times, particularly where permeability is low or seam saturation is unfavourable.
- Incomplete gas removal, with residual gas remaining after drainage.
- Inability of a single in-seam borehole to drain a whole multi-seam open cut sequence.
- Thin, split, undulating, faulted or structurally complex seams that are difficult to drill and maintain in-seam.
- Interburden and non-target seams that may remain gas sources even where selected seams are drained.
- Surface infrastructure, safety controls, water management, maintenance and verification requirements that interact with mining.
- Potential spontaneous combustion implications if dewatering leaves coal drier and more prone to heating.
- Tenure, boundary and over-drainage issues where drainage may extend beyond the intended mined area.

Way Forward

- The next phase should move from generic assessment to site-based evaluation using a practical screening framework.
- Screening should consider seam thickness, gas content, permeability, gas composition, depth, structure, mine schedule, lead time, access and surface infrastructure interaction.
- Representative case-study sites should be selected for data quality, mine planning certainty and practical access, not simply gasiness.
- Site-specific designs should be tested through calibrated modelling, with SIS likely to be the base case for comparison.
- A whole-of-system economic and abatement model should be developed before any conclusions are drawn.
- Subject to satisfactory case-study results, the next step would be a controlled mine-integrated pilot to test performance, maintenance, gas handling, verification and open cut interaction.